WATER SUPPLY FEASIBILITY STUDY

VOL.1

PN-AAK-238

SAN FERNANDO

WATER DISTRICT

MARCH 1978

PREPARED BY: LOCAL WATER UTILITIES ADMINISTRATION
ENGINEERING DEPARTMENT
PLANNING DIVISION

WITH GUIDANCE FROM: CAMP DRESSER & McKEE INTERNATIONAL INC.
PROJECT CONSULTANTS

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5 April 1978

Mr. Carlos C. Leaño, Jr.
General Manager
Local Water Utilities Administration
7th Floor, NIA Building
EDSA, Quezon City

Subject: Final Report - Feasibility Study for Water Supply - San Fernando Water District

Dear Mr. Leaño:

In accordance with the contract between Local Water Utilities Administration (LWUA) and Camp Dresser & McKee International Inc. (CDM) dated 14 October 1974, and amended on 10 August 1976, we take pleasure in submitting this report.

This report is presented in two volumes: Volume I which contains the recommended plan and detailed analysis, and Volume II which contains the support information common to all urban areas covered in the contract.

Extensive improvements and additions to the present water supply system are needed to overcome current deficiencies and to meet future requirements. The recommended plan is the result of detailed alternative studies and extensive cost optimization work. While the cost of the recommended long-range water system facilities is substantial, we consider it within the people's ability-to-pay.

The feasibility studies were done primarily by the LWUA staff assigned to CDM for on-the-job training for the duration of the contract. After guiding the counterpart staff and reviewing this work, we are of the opinion that the planning group has now acquired the necessary technical skills to carry on feasibility studies on their own.

Principal Office:
One Center Plaza, Boston, Massachusetts 02108 USA

Mr. Carlos C. Leaño, Jr.
General Manager
Local Water Utilities Administration
Re: Final Report - Feasibility Study
for Water Supply - San Fernando
Water District
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We wish to extend our thanks to the LWUA Board, all the members of the LWUA staff, the FER-WD staff and the officials of various agencies of the Government of the Philippines, who so generously assisted us during the course of our study.

Very truly yours,

CAMP DRESSER & McKEE INTERNATIONAL INC.

ANTONIO DE VERA
LWUA Planning Manager

LEONARDO V. GUTIERREZ JR.
Vice President/Project Manager

V

FOREWORD

This feasibility study presents the recommended plan for the upgrading and expansion of the water supply system of the San Fernando Water District (FER-WD). This study was made by the Local Water Utilities Administration (LWUA), with the technical assistance of Camp Dresser and McKee International Inc. This study is the result of many months of work in the municipality of San Fernando in Pampanga Province, and is supported by extensive experience with other water districts in the Philippines during the First Ten Provincial Urban Areas Feasibility Studies.

This study was prepared in two volumes: Volume I, the main report, which contains the recommended plan and the methodology memoranda; and Volume II, which contains detailed background information relating to specific sections of Volume I. A complete understanding of the two volumes would require reading the previously published Water Supply Feasibility Studies Methodology Manual (Volumes I and II), a compilation of the handouts used in the six-month long training seminar conducted in 1975 by CDM during the First Ten-Area Feasibility Studies.

The recommended plan is a technically and economically feasible program for providing the FER-WD adequate water supply up to the year 2000. The plan should not be viewed as a rigid plan; every attempt was made to develop a plan compatible with the needs and desires of the water district and of the people. However, during the final engineering design of the recommended facilities, changes could still be made. Design changes would be based on more recent field data, changing priorities of the water district and more economical methods of providing the recommended facilities. Any changes considered in the final design should help to further reduce the expected financial impact of the project.

While the main objective of the Second Ten Provincial Urban Areas Feasibility Studies was the preparation of feasibility reports, another important objective was the training of Filipino counterpart engineers in water supply project planning. The training program which included lectures and on-the-job training aimed to develop local planning capability for water supply projects. The Filipino engineers learned by actually doing the work, with the CDM consultants providing the necessary expertise and guidance.

The following have contributed significantly to the development of the water supply feasibility studies for FER-WD:

Wilfredo Sevilleja, Counterpart Chief Engineer
Reginald Abustan, Group Leader

Renato Navarro, Assistant Group Leader
Roberto Binag, Professional Engineer
Reynaldo Tabao, Professional Engineer
Jean Casten, Economist
Celso Razal, Jr., Economist
Lourdes Gutierrez, Technical Writer
Dionisio Polintan, FER-WD General Manager

The following project staff members have also contributed to the technical/non-technical work of the studies:

Mario Bermejo, Professional Engineer
Luisito Lacerna, Professional Engineer
Rommel Liamco, Professional Engineer
Meliton Avillanosa, Field Technician
Alberto Machica, Draftsman
Meredith Maraño, Secretary/Typist
Ceasar Florendo, Printing Assistant
Diosdado Burca, Printing Assistant

The following consultants have provided the guidance during the studies:

James Arbuthnot, Chief Engineer
Eugene Rumph, Hydrogeologist
James de Young, Water Supply Engineer
Bruce Conklin, Systems Engineer

LIST OF ABBREVIATIONS

Organizations

ADB	Asian Development Bank
BAN-WD	Bangued Water District
BAY-WD	Baybay Water District
BIS-WD	Bislig Water District
CAL-WD	Calamba Water District
CDM	Camp Dresser & McKee International Inc.
COT-WD	Cotabato City Water District
DCCD	Design Consultation Construction and Development Engineering Corporation
FER-WD	San Fernando Water District
GAP-WD	Gapan Water District
IBRD	International Bank for Reconstruction and Development
LB-WD	Los Baños Water District
LWUA	Local Water Utilities Administration
MWSS	Metropolitan Waterworks and Sewerage System (formerly National Waterworks and Sewerage Authority or NWASA)
NEDA	National Economic Development Authority
NIA	National Irrigation Administration
NWRC	National Water Resources Council
OLO-WD	Olongapo City Water District
PAGASA	Philippine Atmospheric, Geophysical and Astronomical Services Administration
ROX-WD	Roxas City Water District
SIL-WD	Silay City Water District
URD-WD	Urdaneta Water District
USAID	United States Agency for International Development

Units

AC	asbestos cement
CCI	centrifugally cast iron
CI	cast iron
cm	centimeter
cum	cubic meter
cumd	cubic meter per day
cumd/ha	cubic meter per day per hectare
cum/hr/sqkm	cubic meter per hour per square kilometer
cumd/m	cubic meter per day per meter
cum/mo	cubic meter per month
cum/sqkm/yr	cubic meter per square kilometer per year
FEC	foreign exchange component
GI	galvanized iron
GS	galvanized steel

ha	hectare
HGL	hydraulic grade line
hr	hour
kg	kilogram
km	kilometer
lpcd	liter per capita per day
lpd	liter per day
lps	liter per second
lps/m	liter per second per meter
m	meter
m/ha	meter per hectare
mg/l	milligram per liter
min	minute
mm	millimeter
mm/yr	millimeter per year
mo	month
m/sec	meter per second
MSL	mean sea level
%	percent
₱	Philippine peso
pH	logarithm (base 10) of the reciprocal of the hydrogen ion concentration in water, moles per liter
PVC	polyvinyl chloride
RU	revenue unit
sqkm	square kilometer
sqmd	square meter per day
$	United States dollar
yr	year

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CHAPTER I SUMMARY AND RECOMMENDATIONS

A. SUMMARY OF STUDIES

Description

The San Fernando Water District (FER-WD) was formed on 16 December 1976 by virtue of Resolution No. 94 of the Sangguniang Bayan (municipal council) of San Fernando. The FER-WD includes the entire municipality of San Fernando in the Pampanga Province. Following its formation, FER-WD acquired the ownership and management of the entire water system in accordance with Presidential Decree No. 198 (The Provincial Water Utilities Act of 1973).

San Fernando is situated in the southeastern portion of Pampanga Province on the Central Plain of Luzon. San Fernando consists of 34 barrios and its poblacion with a total land area of 90 sqkm.

The population of San Fernando was 84,362 in 1970 and is considered 100 percent urban in composition.

Existing Water System

The existing water system of FER-WD was originally constructed in 1929 with a well as its original source of supply. Four additional wells were constructed in later years. The production of the five wells was estimated to be 3,980 cumd in May 1977.

Storage facilities for FER-WD consist of two 380-cum concrete elevated storage tanks located in barrios Lourdes and Dolores. The tank in Barrio Lourdes is presently not used due to its poor structural condition. The tank in Barrio Dolores is being used on a "fill-and-draw" basis.

The distribution system consists of about 13 km of 50, 75, 100, 125 and 150-mm pipelines. Most of the pipelines are cast iron and were constructed in 1929. There are about 23 known valves and 54 fire hydrants in the system.

Projections

The present service area of FER-WD includes the more densely populated sections of the poblacion (which includes barrios Sta. Teresita and Lourdes) and the barrios of Sta. Lucia, San Pedro, Dolores, Juliana, Del Pilar, San Jose, San Juan and Sto. Niño. The service area is expected to include the barrios of San Nicolas, San Agustin, San Felipe, Quebiauan, San Isidro and Del Rosario by the year 2000.

The population in the FER-WD service area was 76,549 in 1975 and is projected to increase to 165,210 by the year 2000. During the same period the population served by the FER-WD is expected to increase from 8,715 to 109,580.

The per capita demand of water is expected to be 230 lpcd in 1980 with a total average daily demand of 3,910 cumd. The per capita demand is expected to decrease to 220 lpcd in 1990 due to improved water accountability and then increase to 225 lpcd in 2000. The estimated total average daily demand is 12,020 cumd in 1990 and 24,660 cumd in 2000.

Water Resources

San Fernando is located over a fairly good, widespread, relatively uniform aquifer that probably can supply all its projected water demands past the year 2000 from deep wells each producing 30 lps or more. The quality of the groundwater is expected to be favorable with no treatment required other than disinfection. However, the regional drawdown effects of wells in FER-WD may become critical. Overproduction of groundwater is inevitable and is already occurring. The static water level has declined over 8 meters in about 20 years at the present rate of pumping. This overproduction will result not only in higher production costs but also in salinization of the groundwater that will limit or destroy its usefulness.

Induced infiltration wells drilled in the sands and gravel of local river floodplains were also considered. However, such wells are not practical because: (1) the water of the smaller rivers and of the lower reach of the Pampanga River is frequently saline, and (2) all of the rivers are incised in narrow channels, consequently lacking the broad sandy floodplain deposits necessary for the successful operation of induced infiltration wells.

Three surface water sources were also evaluated as potential sources for FER-WD. One potential surface source, using a number of small rivers close to San Fernando, including the San Fernando River which runs through the poblacion, was discovered to be undesirable for water supply. The water is too saline and the minimum flows are too low for the FER-WD requirements in the year 2000. The other two potential surface water sources, the Pampanga River and the rivers of the mountains 20 km to the west of San Fernando, are technically feasible but their use would require treatment and transmission facilities.

Alternative Studies

Present worth analyses show that groundwater from deep wells within the San Fernando service area is the most practical and economical water source for FER-WD over the project planning period. Surface water sources or induced infiltration wells from the Pampanga River were also analyzed and found not to be cost-effective for FER-WD.

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An economic analysis of storage requirements versus supply capacity shows that, in the FER-WD, providing additional pumping capacity to meet hourly fluctuations in demand would be less costly than providing extra storage volume. It is recommended therefore to provide source facilities capable of supplying peak-hour demands and minimize storage capacity.

An analysis of pressure requirements in FER-WD indicates that the system could be operated satisfactorily from one pressure zone. The requirements for the distribution system were analyzed with the aid of a computer and the recommended system is included in detail in Chapter IX.

B. RECOMMENDATIONS

General

A water supply system utilizing wells located throughout the FER-WD as the source is recommended for FER-WD. Construction of new wells and improvement of the distribution system and administrative facilities will be implemented during an immediate improvement program and a long-range construction program divided into four phases. The salient features of the recommended long-term project for FER-WD are summarized in Table I-1 and shown in Figure IX-1 (appended).

Source

In the year 2000 a total of 14 wells have been constructed to meet most peak-hour demand conditions. Each well, with a capacity of 2,725 cumd will be constructed, complete with pumphouse, miscellaneous mechanical equipment and chlorination facilities. Some wells will be equipped with dual drive facilities to meet average-day water demands during power outages. Pumping levels should be carefully monitored to determine the effects of future groundwater pumping in this region.

The FER-WD should file an application with the National Water Resources Council to secure rights to water sources that they intend to exploit in the future.

Distribution Facilities

The existing distribution system will be largely replaced by the year 1990 and will be expanded to serve 6 barrios in addition to the poblacion and 8 currently served barrios. Approximately 41 km of pipelines varying from 100 to 250 mm in diameter will be constructed as replacement pipelines or new pipelines by 1990. By 2000 another 12 km of distribution pipelines will be constructed.

The FER-WD will install internal network pipelines to cover about 660 hectares and add 18,700 new service connections to the existing system by 2000. All of the existing and new services will be metered.

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TABLE I-1

SUMMARY OF PROPOSED WATER SUPPLY IMPROVEMENTS
SAN FERNANDO WATER DISTRICT

	Immediate Improvement Program	Construction Phase I-A	Construction Phase I-B	Construction Phase II-A	Construction Phase II-B
Construction Period	1978-1979	1980-1985	1986-1990	1991-1995	1996-2000
Total Project Cost (₱ x 1000)	8,254	14,411	12,869	17,371	16,760
Foreign Exchange Component*	3,965	6,954	5,555	7,912	7,626
Source Development	Obtain legal water rights, complete 1 new well pump station.	Construct 2 additional well pump stations.	Construct 3 additional well pump stations.	Construct 4 additional well pump stations.	Construct 4 additional well pump stations.
Distribution	See Table IX-1 100 mm - 9.1 km 150 mm - 5.2 km 200 mm - 5.6 km 250 mm - 0.15 km	See Table IX-3 100 mm - 1.6 km 150 mm - 4.0 km 200 mm - 7.6 km 250 mm - 0.10 km	See Table IX-5 100 mm - 1.2 km 150 mm - 2.1 km 200 mm - 4.1 km 250 mm - 0.18 km	See Table IX-7 200 mm - 5.6 km 250 mm - 1.0 km	See Table IX-9 200 mm - 2.8 km 250 mm - 2.2 km
Storage	-	-	Construct new 380 cum elevated storage tank.	-	-
Internal Network	Leakage survey and repair	151 hectares	99 hectares	216 hectares	195 hectares
Service Connections	Repair 125 Add 1,250	Repair 1,120 Add 3,620	Add 3,015	Add 5,400	Add 5,410
Hydrants	Repair existing hydrants	468 hectares	115 hectares	248 hectares	223 hectares
Miscellaneous	Administrative facilities and equipment, plumbing shop and equipment, vehicles.				

*All foreign exchange figures used in this report were synthesized from data based on actual costs in U.S. dollars. To be consistent with previous studies, these foreign exhchange costs were converted to R.P. pesos at a rate of U.S. $1.0 = R.P. ₱7.0. To obtain correct current foreign exchange costs, multiply those presented in this report by the ratio of the current exchange rate and 7.0. The actual local component of costs (in pesos) is as presented herein.

Storage

The existing 380-cum elevated storage tank in Barrio Lourdes will be completely abandoned while the other 380-cum elevated storage tank in Barrio Dolores will be adequate through Phase I-A. During Phase I-B, 380-cum of additional storage will have to be constructed at the site of the Barrio Dolores elevated storage tank.

Capital Cost Summary

The capital costs for each phase of construction, including the immediate improvement program, are summarized in Table I-2. A more detailed breakdown of costs for the immediate improvement program and Phase I-A is given in Table I-3 (July 1978 price levels).

TABLE I-2

CAPITAL COST SUMMARY

Construction Phase	Construction Period	Construction Cost (₱)	Project Cost (₱) Local	FEC*	Total
Immediate Improvement Program	1978-79	6,577,700	4,288,900	3,965,000	8,253,900
I-A	1980-85	11,660,500	7,456,900	6,954,200	14,411,100
I-B	1986-90	10,312,100	7,314,200	5,554,900	12,869,100
II-A	1991-95	14,017,000	9,458,900	7,911,800	17,370,700
II-B	1996-2000	13,534,800	9,133,800	7,625,900	16,759,700
Total		56,102,100	37,652,700	32,011,800	69,664,500

Annual Operation and Maintenance Costs

Annual operation and maintenance costs are expenses incurred for personnel salaries and benefits, power, chemicals, maintenance and miscellaneous expenses. Estimates of the annual operation and maintenance costs of the water district (based on July 1978 price levels) are given in Table I-4.

Financial Feasibility

The financial feasibility analysis made for the study establishes a detailed set of guidelines that the water district management may use in making decisions during the next few years. A plan has been developed to indicate the manner and time funds will be used to operate

*US $1.00 = ₱7.00

TABLE I-3

COST SUMMARY OF IMMEDIATE IMPROVEMENT PROGRAM AND CONSTRUCTION
STAGE I PHASE A

Item	Local	Foreign*	Total
Immediate Improvement Program			
Source Facilities			
Well and Pumphouse	431,000	122,000	553,000
Disinfection Facilities	25,600	69,200	94,800
Distribution Facilities			
Leakage Detection and Repair	74,700	93,700	168,400
Distribution System Pipelines	1,748,000	1,642,200	3,390,200
Service Connections			
Installation, Conversion and Repair	523,300	882,300	1,405,600
Administrative and Miscellaneous			
Administrative Building & Equipment	400,600	55,800	456,400
Laboratory, Plumbing & Meter Repair Shop & Equipment	195,700	180,600	376,300
Vehicles	60,000	60,000	120,000
Miscellaneous	5,000	8,000	13,000
Total Construction Cost	3,463,900	3,113,800	6,577,700
Contingencies	490,300	419,500	909,800
Engineering	232,400	431,700	664,100
Land Costs	102,300	-	102,300
TOTAL PROJECT COST	4,288,900	3,965,000	8,253,900
Stage I Phase A Construction			
Source Facilities	1,835,600	798,900	2,634,500
Pipelines and Valves	1,400,200	1,440,100	2,840,300
Internal Network	912,500	656,600	1,569,100
Fire Hydrants	384,700	532,000	916,700
Service Connections	1,622,600	2,077,300	3,699,900
Total Construction Cost	6,155,600	5,504,900	11,660,500
Contingencies	842,200	721,900	1,564,100
Engineering	391,600	727,400	1,119,000
Land Costs	67,500	-	67,500
TOTAL PROJECT COST	7,456,900	6,954,200	14,411,100

*US $1.00 = ₱7.00

TABLE I-4

ANNUAL OPERATION AND MAINTENANCE COSTS (₱)

Item	1977	1980	1990	2000
Administration and Personnel	102,300	181,000	359,200	542,200
Power and Fuel	125,000	176,000	510,600	1,031,600
Chemicals	-	32,100	91,300	184,000
Maintenance	51,000	67,500	161,700	403,100
Miscellaneous	10,000	13,300	34,500	89,500
Total	288,400	469,900	1,157,300	2,250,400

and maintain the system; implement the program; establish reserve funds; and retire the indebtedness. Water rates have been developed on the basis that the system will be financially self-supporting. These rates appear to be within the ability-to-pay of the average FER-WD householder.

The recommended water rates by revenue unit are as follows:

	Rate/RU
1978-1980	₱0.75
1981-1984	1.10
1985-1987	1.20
1988-1990	1.30
1991-1993	1.50
1994-1996	1.70
1997-2000	1.90

It is recommended that the implementation of these rates follow a socialized pricing policy to make the financial burden on the consumers proportionate to their ability-to-pay. A sample socialized rate structure for 1978-1980 that would generate sufficient revenue is as follows:

Uasge (per month)	Cost (per cum)
first 16 cum	₱0.85
from 17 to 24 cum	1.85
greater than 25 cum	2.45

Borrowing requirements will include ₱9.837 million from 1978 to 1981 for the immediate improvement program; ₱20.469 million from 1979 to 1985 for Phase I-A improvements; and ₱21.298 million from 1986 to 1990 for Phase I-B improvements.

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Economic Feasibility

The recommended improvements to the FER-WD water supply system will bring about numerous economic benefits to the study area. Economic feasibility studies show that the benefits will exceed the costs associated with the development and operation of the water system.

Two approaches were adopted to determine economic feasibility: the benefit-cost ratio and internal economic rate of return (IERR). In both approaches, four benefits valued at 1978 prices were included and discounted at 12 percent. The benefits considered are increase in land values, health, reduction in fire damage and beneficial value of water. Analysis shows a benefit-cost ratio of 1.52:1 and an IERR of 42.72 percent.

CHAPTER II. INTRODUCTION

A. FIRST TEN PROVINCIAL URBAN AREAS

The study contract signed by the Local Water Utilities Administration[1] (LWUA) and Camp Dresser & McKee International Inc. (CDM) on 14 October 1974 provided for the feasibility studies for the First Ten Provincial Urban Areas[2] (see Figure II-1). The feasibility studies are part of LWUA's effort to develop basic water supply plans for provincial urban areas of the Philippines.

During the first 10-area project, training seminars for LWUA engineers were conducted by the CDM staff. "The Methodology Manual for Water Supply Feasibility Studies" was also developed and printed. In addition to the 10 areas, prefeasibility studies were made for 131 cities/municipalities[3]. As of August 1976, the feasibility studies were completed and submitted to LWUA.

The studies for five of the first 10 areas - Cebu, Zamboanga, Daet, Ozamiz and Butuan - have been appraised by the Asian Development Bank (ADB). On the basis of the interim reports, the ADB extended a $16.8 million loan to LWUA in December 1975 to provide design engineering services to these 5 areas and to implement Phase I-A of the recommended long-term construction program (except Cebu whose share of the loan covered only engineering services). In August 1976, the United States Agency for International Development (USAID) signed a $10 million loan with LWUA to provide engineering services and funds for the implementation of the interim improvements of selected waterworks covered by the prefeasibility studies. In April 1977, the International Bank for Reconstruction and Development (IBRD) allocated $18.8 million towards the final design and initial phase implementation of the remaining five of the first 10 areas, namely: Lipa, Lucena, Tarlac, Cabanatuan, and San Fernando (La Union).

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[1] A background on LWUA is given in Volume II, Appendix D.

[2] Refer to Appendix B for summary of first 10-area feasibility studies.

[3] Refer to Appendix C for summary of prefeasibility studies of 131 cities/municipalities.

B. SECOND TEN PROVINCIAL URBAN AREAS

On 10 August 1976, LWUA and CDM signed an amendment to the original study contract, extending the feasibility studies to include the Second Ten Provincial Urban Areas.4/ These are Urdaneta, Gapan, Calamba, Bislig, Silay City, Bangued, Baybay, Roxas City, Cotabato City, San Fernando (Pampanga), Olongapo City and Los Baños (see Figure II-1). This report includes the technical, financial and economic studies for the improvement of the water supply system in San Fernando, Pampanga.

The dollar component of the second 10-area feasibility studies has been financed from proceeds of a loan to the Government of the Republic of the Philippines from the United States of America through the USAID, Loan No. 492-T04001 dated 9 September 1976. The peso component of the studies, approximately 41 percent, has been funded by the Government of the Philippines.

The study contract for the second 10 areas includes the following tasks:5/

1. Training of counterpart LWUA engineers through on-the-job assignments on various aspects of water supply feasibility studies;

2. Preparing water supply feasibility studies for 5 provincial urban areas, using the expatriate and local consultant personnel for conducting such studies;

3. Preparing water supply feasibility studies for additional 5 urban areas, with the LWUA engineers taking a dominant role in the conduct of such studies.

The studies began on 1 September 1976 for a period of 18 months. The project staff was composed of 6 US engineers and 26 Filipino personnel. The personnel of the respective water districts also assisted during the course of the studies.

4/ Although the inclusion of 10 areas is stipulated in the contract, feasibility studies for 12 areas have actually been made.

5/ Refer to Appendix A, Volume II for complete Terms of Reference.

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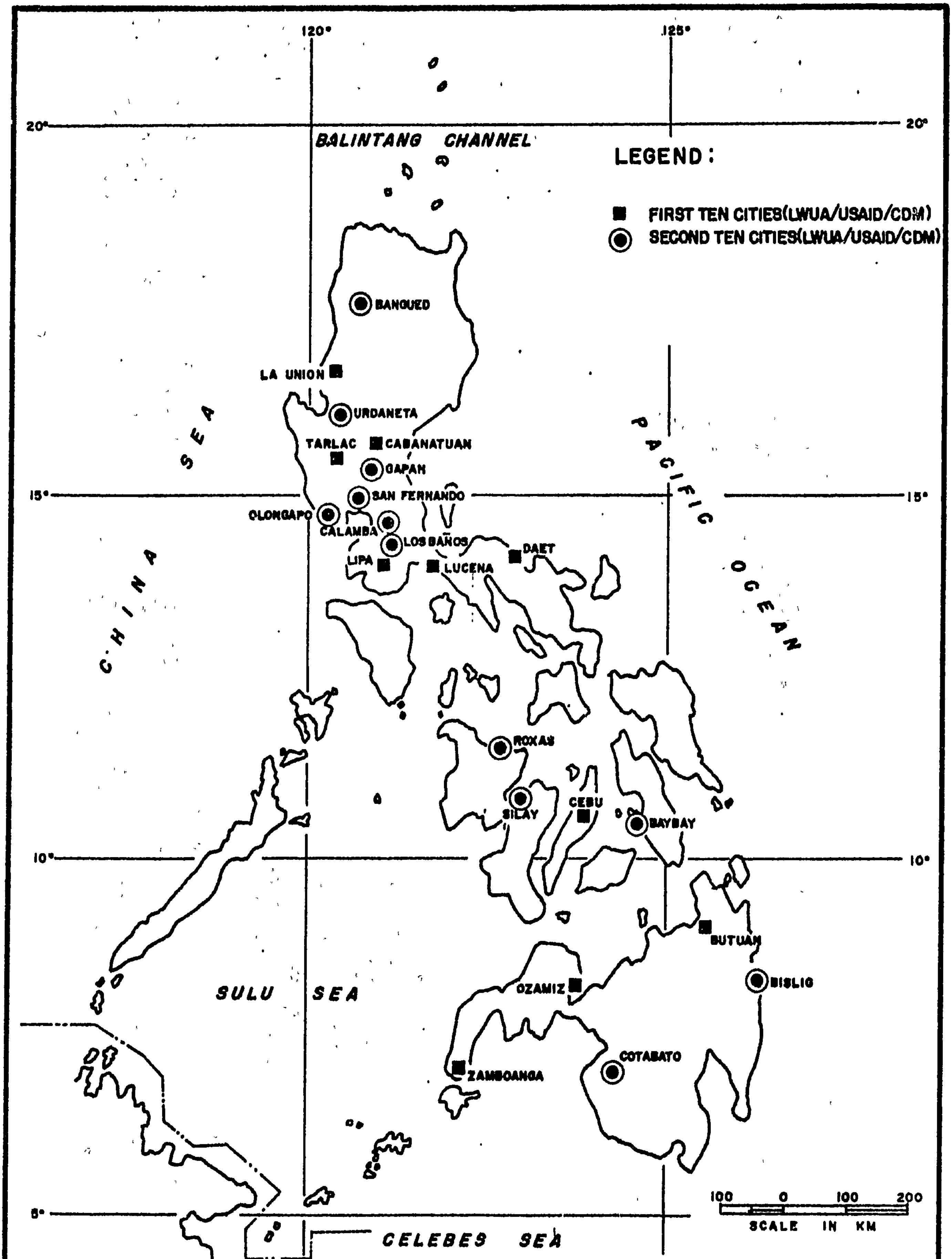

FIGURE II-1
LOCATION MAP
REPUBLIC OF THE PHILIPPINES

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

C. HISTORICAL BACKGROUND OF SAN FERNANDO WATER DISTRICT

When constructed in 1929, the water supply system of San Fernando was owned and managed by the municipal government. In 1956, however, the water system was placed under the National Waterworks and Sewerage Authority (currently Metropolitan Waterworks and Sewerage System) which was founded to take charge of provincial water utilities. NWASA turned over the system to the municipal government in 1964.

The FER-WD was established on 16 December 1976 by Resolution No. 94 of the Sangguniang Bayan (municipal council) of San Fernando to include the entire municipality. Subsequently, FER-WD acquired the ownership and management of the water system from the municipal government in accordance with Presidential Decree (PD) 198 (The Provincial Water Utilities Act of 1973).

The formation of the FER-WD was prompted by the need for adequate water supply and an upgraded water system. Limited funding prevented substantial improvements to the system. Moreover, the local officials recognized the potential role of the water district in providing sufficient, safe and potable water supply.

The FER-WD was thus formed for the purposes of acquiring, installing, improving, maintaining and operating the water supply system, as well as the wastewater collection, treatment and disposal facilities. To perform these functions, the FER-WD can obtain financial and technical assistance from LWUA. PD No. 198 provides that the water district shall operate eventually on a financially self-sufficient basis.

The FER-WD is a quasi-public corporation and is politically independent from the local government. As constituted, the water district is subject to the provision of PD No. 198 and the rules and regulations of LWUA. The FER-WD can promulgate its own operating laws through its 5-member board of directors who are appointed by the municipal mayor. The district can only be dissolved through the act of this board.

On 6 May 1977, LWUA awarded the Conditional Certificate of Conformance to the FER-WD after it had complied with the minimum requirements of LWUA's certification program. This certificate entitles the FER-WD to rights and privileges authorized under PD No. 198.

CHAPTER III DESCRIPTION OF THE WATER DISTRICT[1]

A. PHYSICAL DESCRIPTION

San Fernando is located in the southeastern portion of Pampanga Province[2] on the Central Plain of Luzon. San Fernando, the provincial capital, is divided into the poblacion[3] and 34 barrios[4], with a total land area of 90 sqkm.

The present service area[5] (206 hectares) of the FER-WD is situated in the central part of the municipality. It covers the more densely populated sections of the poblacion (which includes barrios Sta. Teresita and Lourdes) and the barrios of Sta. Lucia, San Pedro, Dolores, Juliana, Del Pilar, San Jose, San Juan and Sto. Niño. The service area by the year 2000 will extend to the barrios of San Nicolas, San Agustin, San Felipe, Quebiauan, San Isidro and Del Rosario (see Figures III-1 and VI-1).

Physical Features

The municipal terrain is generally flat in the service area and gradually rises towards the northwestern portion of the municipality. Elevations range from 4 meters above mean sea level (MSL) in Barrio San Nicolas to 30 meters above MSL in Barrio del Rosario.

The main rivers are Pampanga River, one of the principal bodies of water in Luzon; and San Fernando River, a tributary of Pampanga River. The San Fernando River traverses the municipality in a northeast-to-southwest direction.

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[1] The FER-WD covers all lands within the geographic boundaries of San Fernando.

[2] Pampanga, one of the major development areas in the Philippines, is located on the central part of the Central Plain of Luzon. Its boundaries include Zambales on the west; Bulacan on the east; Tarlac on the north; and Manila Bay on the south.

[3] Town proper

[4] A barrio is a political division of a municipality.

[5] The service area represents sections of the water district which are currently served or intended to be served by the water system.

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San Fernando is classified under the Type 1 climate, with two pronounced seasons (Figure III-2). The wet season falls between the months of May and October; the dry season occurs during the rest of the year. The average annual rainfall for the period 1960-69 was 2,055 mm. For the same year, temperature ranged from 25.6°C in January to 29.4°C in May, with the average at 27.5°C. The climatological data are listed in Table III-1.

TABLE III-1

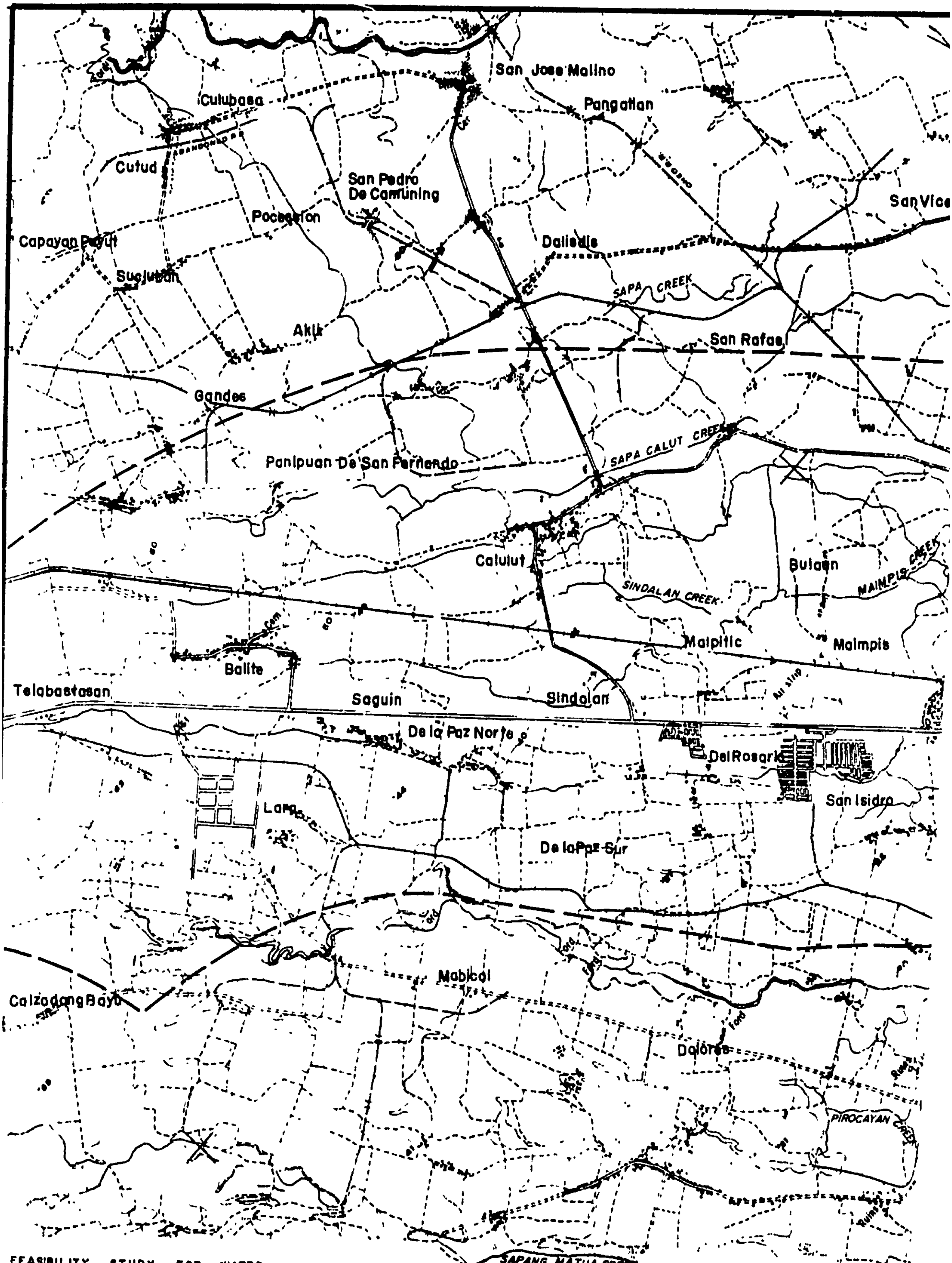
CLIMATOLOGICAL DATA[6/]
(1960-69)

	Rainfall (mm)	Temperature (°C)
January	10.0	25.6
February	6.6	25.9
March	8.5	27.4
April	20.8	28.7
May	151.2	29.4
June	311.6	28.8
July	388.6	28.0
August	448.9	27.6
September	395.5	27.5
October	160.0	27.7
November	113.5	27.4
December	39.5	26.2
Total	2,054.7	
Average		27.5

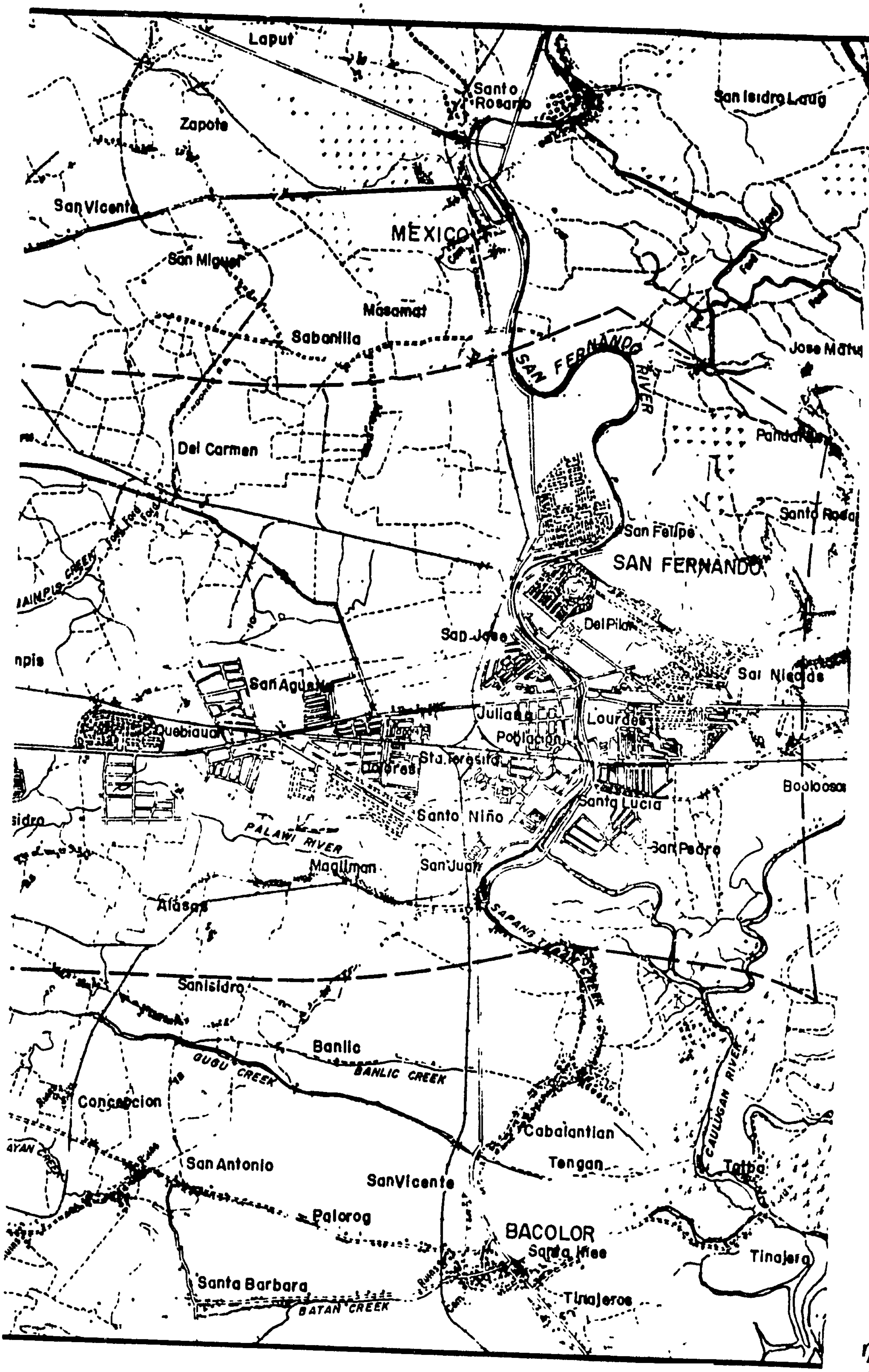
B. POPULATION

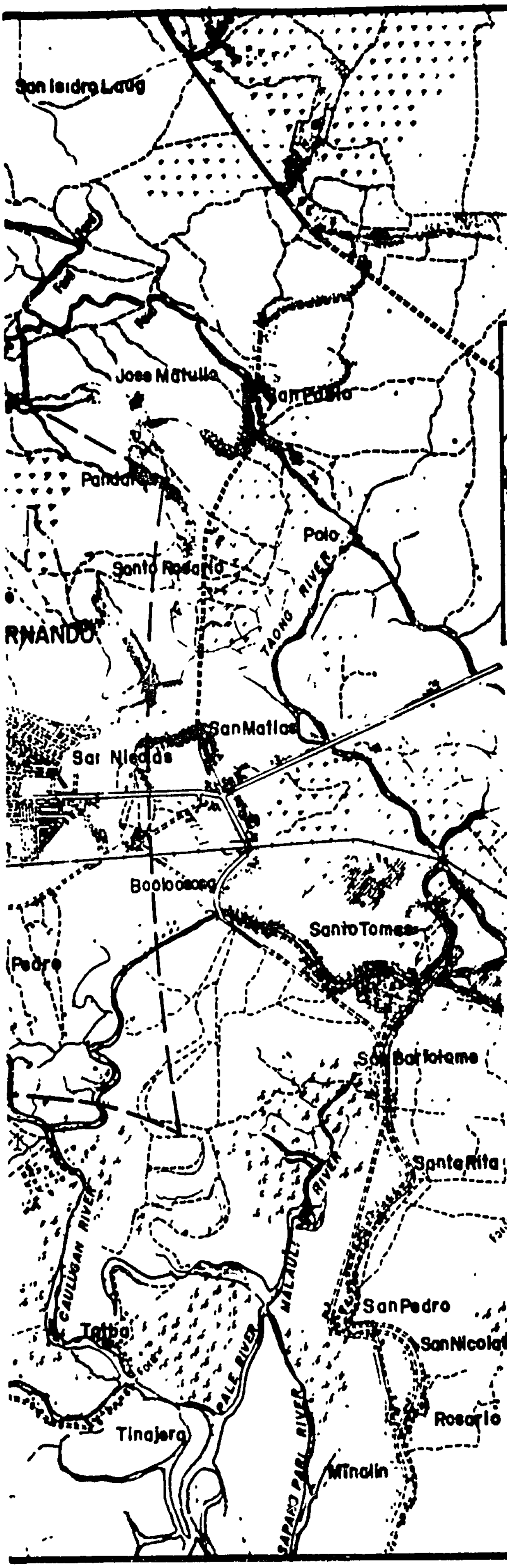
The population of San Fernando in 1970 was 84,362, an increase of 48 percent over the 1960 total of 56,861. In 1970 the municipality had a total of 12,172 households or an average of 6.9 members per household. The general characteristics of the population are listed in Table III-2.

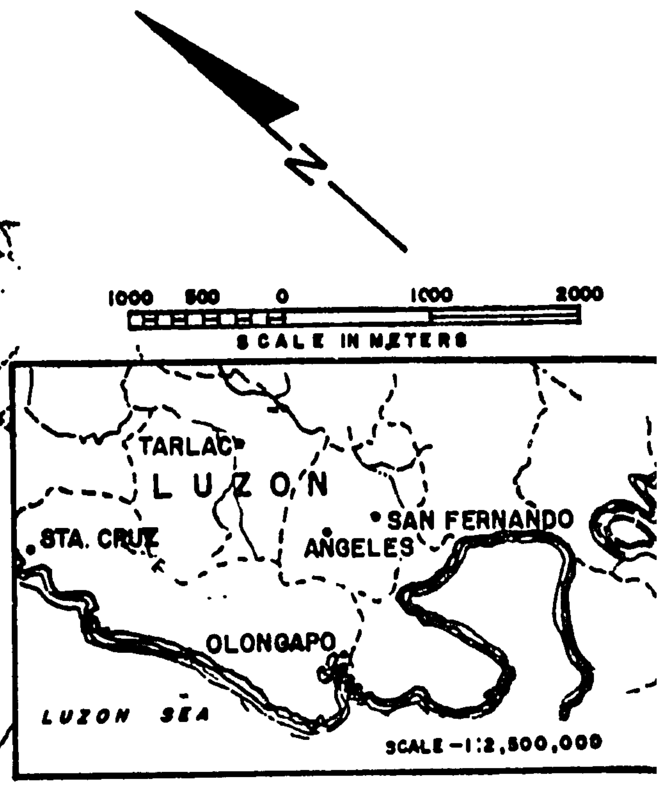
6/ Source: PAGASA station in Manila.



FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM


Laput
Santo Rosario
San Isidro Laug
Zapote
San Vicente
MEXICO
San Miguel
Masamat
Sabanilla
SAN FERNANDO RIVER
Del Carmen
San Felipe
SAN FERNANDO
Del Pilar
San Jose
San Agustin
Juliana
Lourdes
Poblacion
Sta. Teresita
Dolores
Santo Niño
Santa Lucia
San Pedro
PALAWI RIVER
Magliman
San Juan
Alasas
Sanisidro
Banlic
GUGU CREEK
BANLIC CREEK
Concepcion
Cabalantian
Tengan
San Antonio
SanVicente
Palarog
BACOLOR
Santa Barbara
BATAN CREEK
Tinajeros
Tinajero
CAULIGAN RIVER

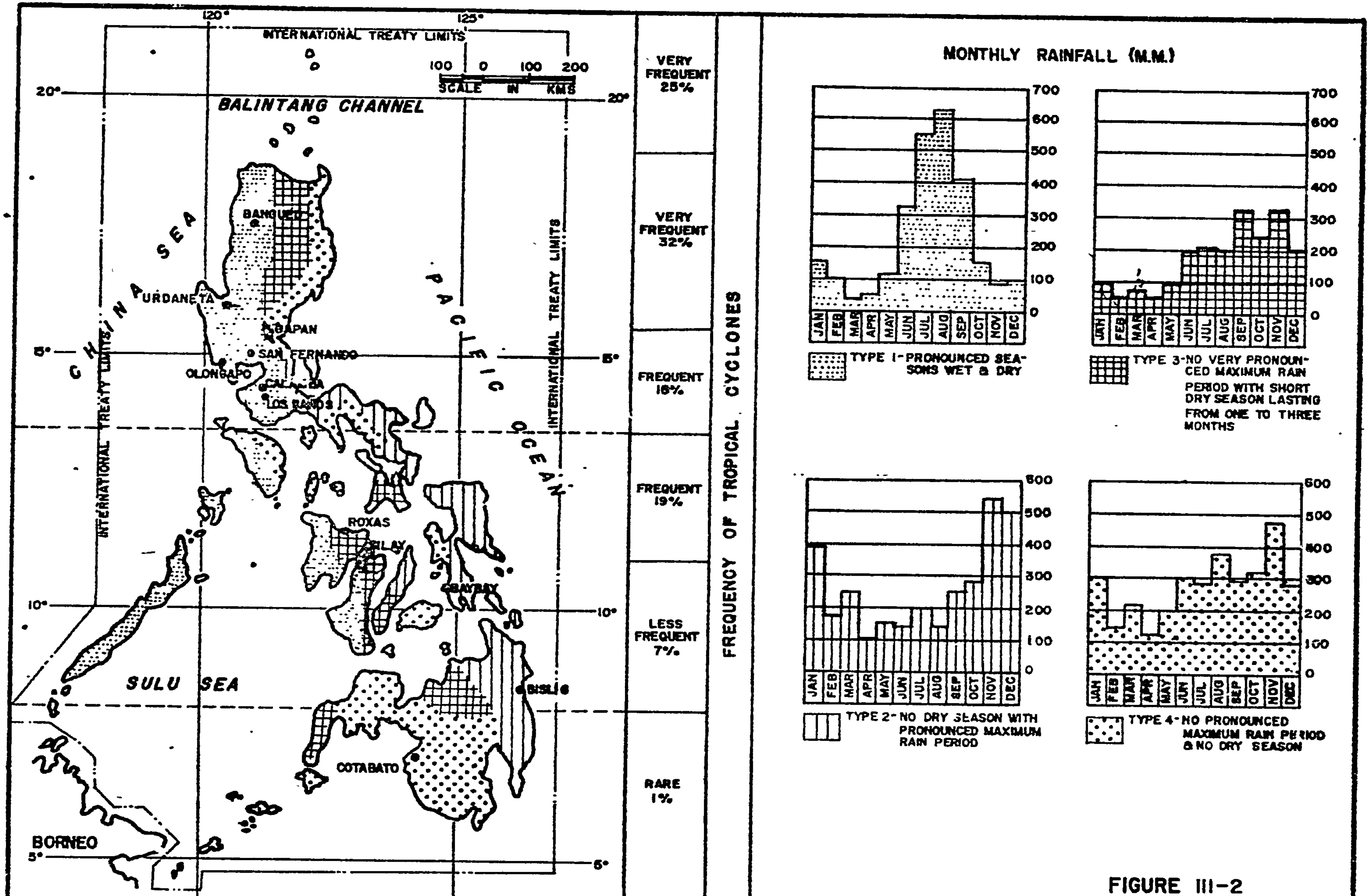




LEGEND:

- - - - - MUNICIPAL BOUNDARIES

FIGURE III-1
LOCATION MAP
SAN FERNANDO WATER DISTRI[CT]



FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS

LWUA-CDM

FIGURE III-2
CLIMATE MAP
REPUBLIC OF THE PHILIPPINES

TABLE III-2

MUNICIPAL POPULATION CHARACTERISTICS 1/ (1970)

1.	Total Population	84,362
2.	Growth Rate (1960-1970)	4.0% per annum
3.	Density	9.37 persons per hectare
4.	Urban/Rural Composition	100% urban
5.	Sex Composition	male, 50%; female, 50%
6.	Age Composition	0-14 years, 46%; 15-64 years, 52%; 65 years and over, 2%
7.	Employment (% of those 10 years and over)	10 years and over, 56,698 employed, 41%; unemployed, 59%
	a) By class of worker (% of labor force)	workforce, 23,282 wage and salary, 73%; own business, 19%; unpaid family workers, 8%
	b) By industry (% of labor force)	agriculture, forestry, fishing, 10%; manufacturing, 18%; commerce, 17%; services, 29%; construction, 7%; utilities, minor industries, 19%
8.	Education (% of those 6 years and over)	6 years and over, 66,819 literate, 87%; illiterate, 13%
	a) By attainment (% of those 25 years and over)	25 years and over, 27,964 elementary grades, 57%; high school, 20%; college, 13%; no formal education, 10%
	b) Number of Schools	elementary, 24; high school, 19; college, 4
9.	Dialects	Pampango, 93%; Tagalog, 4%; others 3%
10.	Religion	Catholic, 97%; others, 3%

1/ Source: 1970 Census of Population and Housing, National Census and Statistics Office (NCSO)

This information applies to the municipality of San Fernando as a whole

C. LIVING CONDITIONS

Physical indicators showing the standard of living in San Fernando are listed in Table III-3. These indicators include types of dwelling units, household facilities and utilities.

Health

Water-borne diseases occur particularly in the more densely populated sections of the municipality. Public health authorities recognize the correlation between the lack of safe water supply and sewerage facilities and the incidence of water-borne diseases. Table III-4 shows the recorded morbidity and mortality rates per 100,000 population due to water-borne diseases in the province of Pampanga[8/] from 1964 to 1974. During this period, the average morbidity of 1,248.9 in this province was almost twice the national average of 666.5; however, the average mortality of 23.4 was lower than the national average of 48.1.

Medical services are provided by 4 hospitals, 5 clinics, puericulture centers and rural health units located throughout the municipality.

D. ECONOMY[9/]

Family Income[10/]

In 1975, the province of Pampanga was estimated to include 152,072 families, with a combined annual income of ₱1.1 billion. The average family income of ₱7,319 was higher than the country's average of ₱5,840. The families were divided by income group as follows: below average (₱1,000-3,999), 28 percent; average (₱4,000-₱9,999), 54 percent; upper middle (₱10,000-₱19,999), 14 percent; and high (₱20,000 and over), 4 percent.

Agriculture and Commerce

Agriculture is the most important economic activity in the municipality. The major crops are rice and sugar; the minor crops include corn and coconut.

8/ The only records available are for the province. The morbidity and mortality trends in San Fernando are assumed from these records (see Chapter XI).

9/ The Philippine economy from 1946 to 1976 is discussed in Appendix E, Volume II.

10/ Only provincial data on family income are available at the NCSO.

TABLE III-3

CLASSIFICATION OF HOUSEHOLDS
BY TYPE OF FACILITIES 11/ (1970)

1.	Total Households	12,172
2.	Average Household Size	6.9 members per household
3.	Water Facilities (% of total households)	piped water, 26%; artesian well, 10%; pump, 63%; other sources, 1%
4.	Toilet Facilities (% of total households)	flush/water sealed, 32%; closed pit, 16%; open pit, 12%; public toilet, 2%; no facilities, 38%
5.	Lighting Facilities (% of total households)	electricity, 61%; kerosene, 38%; others, 1%
6.	Appliances (% of total households)	radio, 73%; TV, 15%; refrigerator, 10%
7.	Cooking Fuel (% of total households)	electricity, 6%; kerosene, 28% LPG, 15%; wood, 50%; others, 1%
8.	Total Dwelling Units	12,151
	a) Type of Dwelling Unit	single type, 90%; duplex, 3%; apartment/accessoria, 5%; barong-barong (makeshift houses), commercial, etc., 2%
	b) Roofing Material (% of total units)	durable materials (aluminum/galvanized iron, asbestos, tile/concrete), 83%; non-durable materials, (cogon, nipa, others), 17%

11/ Source: 1970 Census of Population and Housing, NCSO
This information applies to the municipality of San Fernando as a whole.

TABLE III-4

REPORTED MORBIDITY AND MORTALITY DUE TO WATER-BORNE DISEASES[12] (1964-74) (PER 100,000 POPULATION)

Year	Pampanga		Philippines	
	Morbidity	Mortality	Morbidity	Mortality
1964	736.3	26.9	846.3	60.2
1965	885.1	24.7	715.8	51.6
1966	981.2	43.6	715.1	61.9
1967	871.8	26.8	572.1	47.6
1968	964.8	25.1	564.8	46.5
1969	1,675.0	17.1	706.9	46.0
1970	1,161.2	13.1	612.8	39.0
1971	1,106.7	19.2	422.5	35.8
1972	2,114.2	25.2	743.4	49.4
1973	1,642.7	19.5	768.4	50.4
1974	1,598.7	16.6	663.8	40.4
Total	13,737.7	257.8	7,331.9	528.8
Average	1,248.9	23.4	666.5	48.1

San Fernando, being the capital of Pampanga Province is a leading commercial center in Luzon. In 1975, business establishments in the municipality totalled 2,136, 70 percent of which were engaged in the wholesale and retail trade and 9 percent, in manufacturing.

Public Utilities

San Fernando can be reached only by land. In 1971, it had about 200 km of paved roads and about 9,000 or 1.9 percent of the total number of registered vehicles in the country. There was a ratio of 107.6 vehicles to every 1,000 population. A railway system connects the town to Metropolitan Manila and other provinces of Luzon.

Communication facilities include 4 telegraph stations, a telephone system and a post office.

The power supply of San Fernando is provided by the privately owned San Fernando Light and Power Company. It generates 665,400 kw of energy through facilities of the National Power Corporation. In addition, the private company has its own stand-by diesel generating units.

[12] Source: Disease Intelligence Center, Department of Health. The water-borne diseases, of which records are available, include typhoid, cholera, dysentery, and gastro-entiritis.

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CHAPTER IV EXISTING WATER SUPPLY FACILITIES

A. GENERAL

San Fernando is served by a water system originally constructed in 1929. The original source of supply was a well which supplied a distribution system covering the poblacion core area. Four additional wells were constructed in later years. Other waterworks facilities include two reinforced concrete elevated tanks, about 13 km of distribution piping, and appurtenant valves and hydrants. Figure IV-1 is a schematic plan of the existing water system.

B. WATERWORKS FACILITIES

Water Source Facilities

The existing FER-WD supply sources are five wells located in the poblacion and nearby barrios. The original well constructed in 1929 is the existing Barrio Lourdes well. It is located inside the San Fernando Elementary School compound on 27th Street at the corner of P. Gomez Street in Barrio Lourdes. The well casing has a diameter of 200 mm and a length of 183 meters; well depth is 183 meters. A turbine pump was installed also in 1929 and driven by an electric motor with a rated horsepower of 30 at 1,760 rpm. The discharge was measured to be 6.4 lps at 0.58 kg/sqcm.

Pump station no. 2 is located along V. Tiomico Street corner Gen. M. Hizon Street in the poblacion. The well which was constructed in 1974 has a combination of casing pipes with respective diameter and lengths of 250 mm and 91 meters, 200 mm and 61 meters; and 150 mm and 61 meters. The depth of the wells is 213 meters. The turbine pump is run by an electric motor with a rated horsepower of 40 at 1,800 rpm. Discharge was measured to be 27 lps at 0.35 kg/sqcm.

Pump station no. 3 is located at the capitol building site in Barrio Sto. Niño. The well was drilled in December 1954 to a depth of 167 meters and redrilled in September 1960 to a depth of 246 meters. The casing consists of two pipes with respective diameters and lengths of 200 mm and 166 meters, and 150 mm and 62 meters. The turbine pump is run by an electric motor with a rated horsepower of 20 at 1,800 rpm. Measured discharge was 7.4 lps at 0.74 kg/sqcm.

Pump station no. 4 is located on P. Mendoza Street at the corner of Abad Santos Street in Barrio Dolores. The well was drilled by the Bureau of Public Works in April 1953 to a depth of 220 meters. Its

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casing consists of two pipes, with diameters and lengths of 200 mm and 120 meters, and 150 mm and 80 meters, respectively. The turbine pump is run by an electric motor with a rated horsepower of 15 at 1,750 rpm. Discharge was measured to be 19.2 lps at 0.56 kg/sqcm.

Pump station no. 5 is located along San Pedro Street in Barrio San Pedro. The well was drilled in April 1958 to a depth of 213 meters. The casing consists of three pipes, with diameters and lengths of 200 mm and 95 meters, 150 mm and 84 meters, and 100 mm and 32 meters, respectively. The deep well turbine installed in 1958 was repaired in 1963. It is beltdriven by a 22-hp diesel engine. Discharge was measured to be 10.8 lps at 0.77 kg/sqcm.

Total production of the existing well sources was estimated to be 3,980 cumd in May 1977.

Storage Facilities

The FER-WD has two reinforced concrete elevated tanks, each with a capacity of 380 cum. The first tank, constructed in 1929 in Barrio Lourdes, has an overflow elevation of about 30 meters above MSL; the second tank, constructed in 1956 in Barrio Dolores, has an overflow elevation of about 34 meters above MSL.

The tank in Barrio Lourdes was recently abandoned because of its leaning position suspected to be a result of structural instability. The tank in Barrio Dolores is used on a "fill-and-draw" basis. The Barrio Dolores pump station pumps water into the tank for 6 hours from 2100 hours to 0300 hours every fourth day. Water from the tank is then distributed for 5 hours from 1300 hours to 1800 hours on the day of filling. About 150 cum of water in this reservoir is retained as fire reserve.

Distribution System

The distribution system has undergone only minor expansion since it was constructed in 1929.

Cast iron mains, 150 mm in diameter, located along the primary streets in the downstream area, serve as the backbone of the distribution grid. The remainder of the system consists of 50 to 125 mm pipes. The present distribution area has adequate water supply at night. A diagram of the present distribution system is shown in Figure IV-2.

Pipe Sizes and Lengths. At present, the distribution system has about 12.83 km of piping ranging in size from 50 to 150 mm. Sixteen percent of the piping is 150 mm in diameter and 45 percent, 75 mm in diameter. Forty-eight percent is galvanized iron piping; the remaining 52 percent is cast iron piping and about 48 years old. Table IV-1 is a description of the distribution system by diameter, material length and period of construction.

DISTRIBUTION SYSTEM

DIAMETER (MM)	TYPE	LENGTH OF PIPE (M) BY YEAR INSTALLED 1929	TOTAL
50	G I	330 *	330
75	G I	5800 *	5800
100	C C I	4550	4550
125	G I	40	40
150	C C I	2110	2110
T O T A L		12,830	12,830

* NO AVAILABLE RECORD WHEN INSTALLED

APPURTENANCES

	SIZE	NUMBER	REMARKS
VALVES	75 MM	14	NOT VERIFIED AS MOST
	100 MM	5	VALVES ARE BURIED UNDER
	150 MM	4	CONCRETE ROADWAYS
HYDRANTS	75MM GS RISER	54	20 ARE INOPERABLE
PUBLIC FAUCETS	N O N E		

SERVICE CONNECTIONS AS OF APRIL 1977

TYPE	METERED	FLAT - RATE	TOTAL
DOMESTIC		902	902
COMMERCIAL / INSTITUTIONAL		343	343
INDUSTRIAL			
T O T A L		1245	1245

DOLORES DEEPWE

- TURBINE PUMP ELECTRIC MOTOR
- CASING DIAMETER 150 MM , 80 M LO
- WELL DEPTH = 220
- DISCHARGE = 19.
- PUMPS TO DISTRIB FOR 2 CONSECUT DISTRIBUTION FR 1800 TO 2100 HRS FROM 2100 TO 03

DOLORES STORA

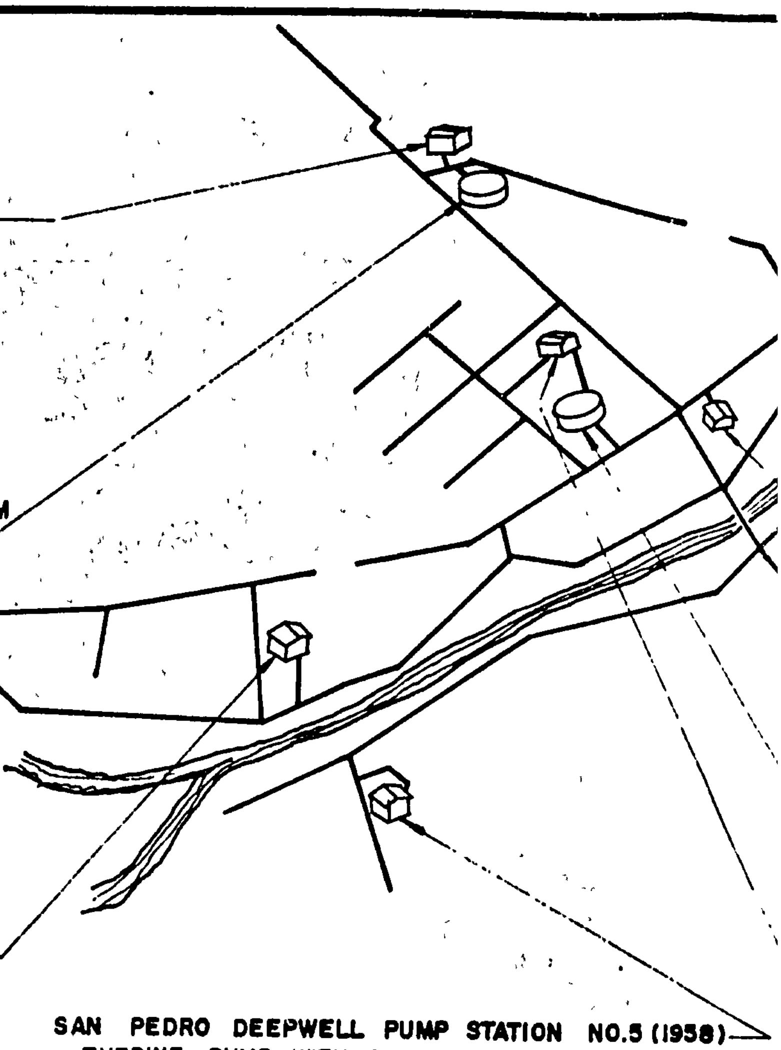
- CAPACITY = 380 C
- OVERFLOW ELEV
- REINFORCED CONC
- ABOUT 150 CUM RESERVOIR FOR
- DISTRIBUTES WAT 1800 HRS ONCE E

STO. NINO DEEPWE

- REDRILLED IN 19
- TURBINE PUMP WI
- CASING DIAMETER AND 150 MM, 62 M
- WELL DEPTH = 246
- DISCHARGE = 74 L
- PUMPS TO DISTRIB 2100 HRS

SYSTEM PRE

- VERY LOW PRESS DISTRIBUTION SY



PWELL PUMP STATION NO. 4 (1953)
MP WITH A 15 HP
TOR.
TER OF 200 MM, 120 M LONG ;
LONG.
220 M
19.2 LPS AT 0.56 KG/SQ.CM.
TRIBUTION FROM 0500 TO 2100 HRS
CUTIVE DAYS : PUMPS TO
FROM 0500 TO 1300 HRS. AND FROM
HRS. AND THEN PUMP TO STORAGE TANK
) 0300 HRS. FOR THE 3RD DAY.

ORAGE TANK (1956)
30 CUM
LEVATION = 34 M MSL
CONCRETE
UM OF WATER IS KEPT IN THIS
OR FIRE RESERVE
WATER FROM 1300 HRS. TO
ICE EVERY 3 DAYS

PWELL PUMP STATION NO. 3 (1954)
N 1960
P WITH A 20HP ELECTRIC MOTOR
ETERS OF 200 MM, 166 M LONG
62 M LONG
= 246 M
7.4 LPS AT 0.74 KG/SQ.CM.
ISTRIBUTION SYSTEM FROM 0530 TO

SAN PEDRO DEEPWELL PUMP STATION NO.5 (1958)
- TURBINE PUMP WITH A 22 HP DIESEL ENGINE DRIVE.
- CASING DIAMETER OF 200 MM, 95 M LONG 150 MM, 84 M LONG; 100 MM, 32 M LONG.
- WELL DEPTH = 213 M
- DISCHARGE = 10.8 LPS AT 0.77 KG/SQ.CM.
- PUMPS TO DISTRIBUTION SYSTEM FROM 0530 TO 1300 HRS. AND 1700 HRS. TO 2200 HRS.

PRESSURE

RESSURE THROUGHOUT THE
N SYSTEM.

SERVICE AREA OPERATION

- MOST CONSUMERS ARE LOCATED IN THE POBLACION AND BARRIOS STA. LUCIA, STO NINO AND SAN JOSE.
- WATER SERVICE IS 16 HRS. A DAY.

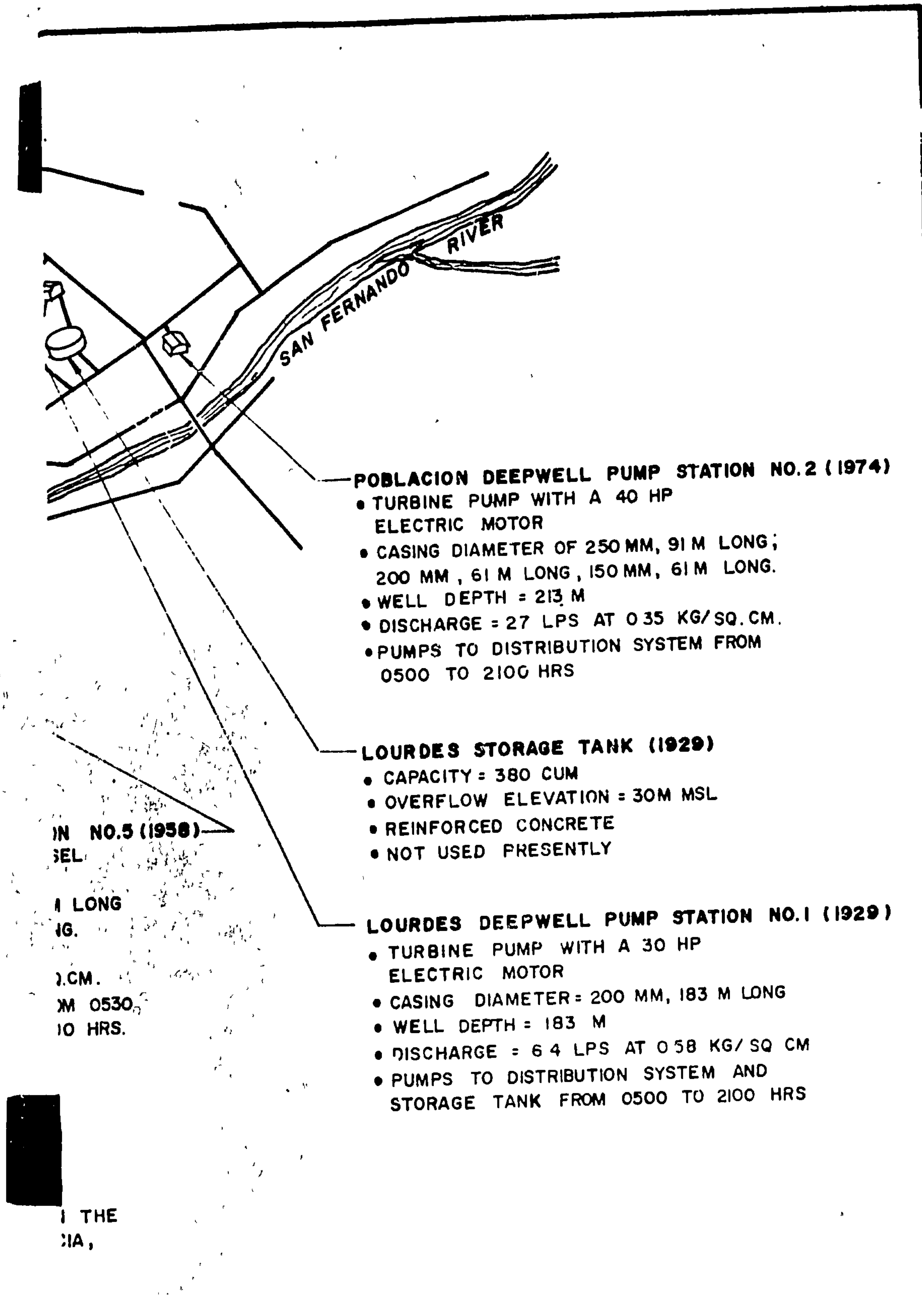
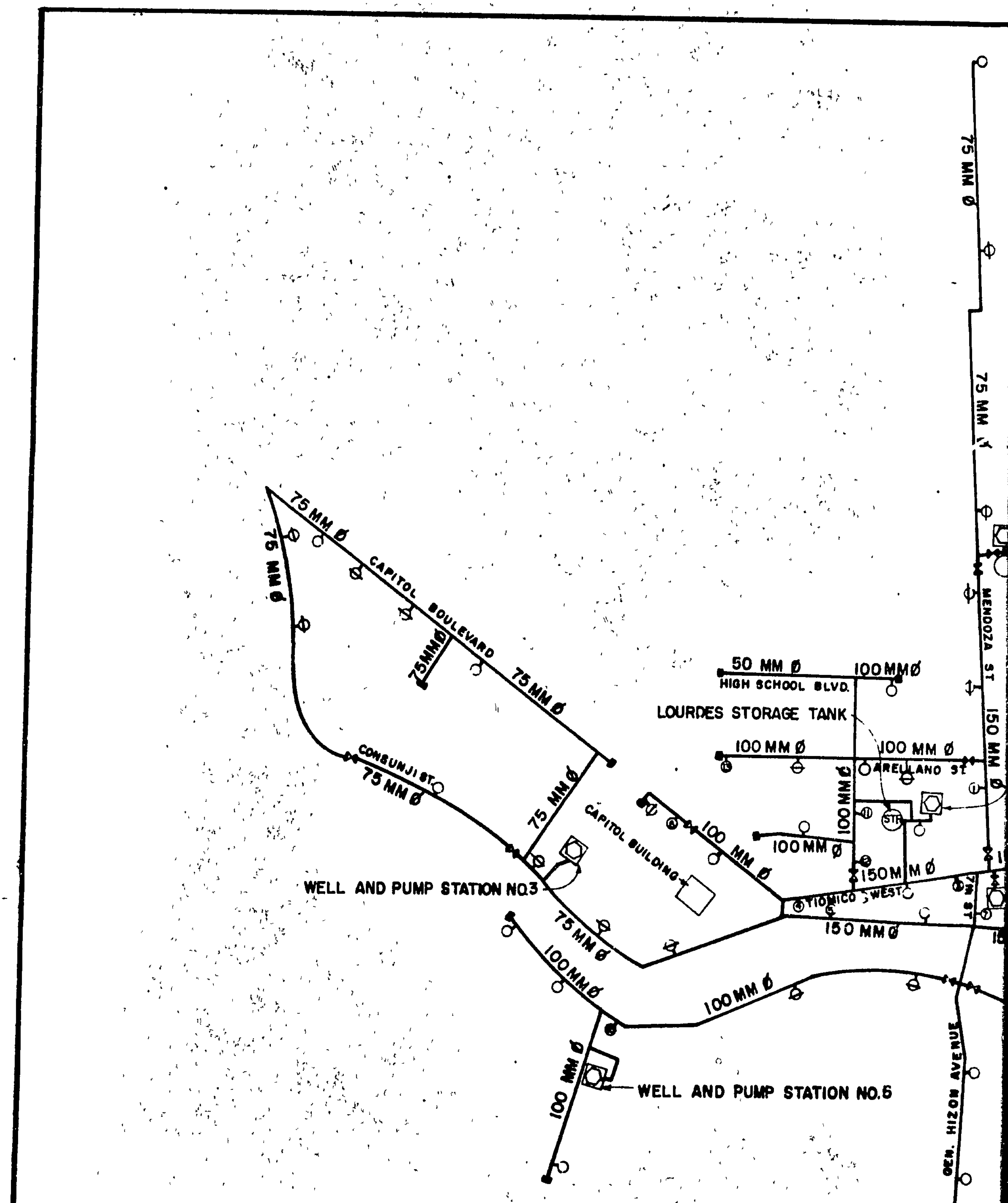
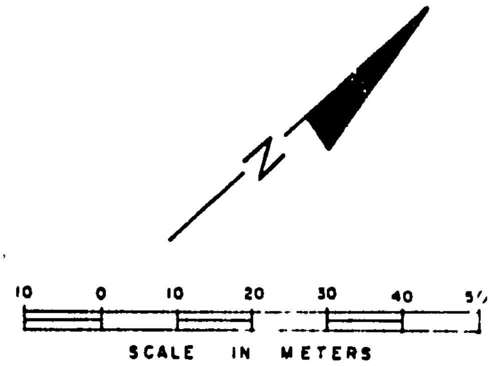
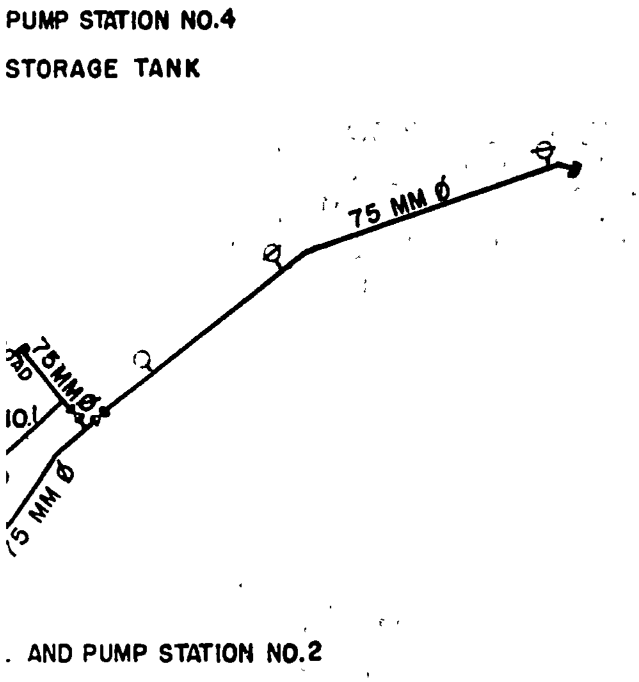


FIGURE IV-1
EXISTING FACILITIES
SAN FERNANDO WATER DISTRICT



FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM





LEGEND:

EXISTING PIPELINE

DEAD END

OPERABLE FIRE HYDRANT

INOPERABLE FIRE HYDR

GATE VALVE

DEEP WELL AND PUMP ST

ELEVATED STORAGE TAN

NOTE: 1. FIRE HYDRANTS WITH NUMBERS ARE PRESSUR READING AND FLOW TESTS LOCATIONS, REFER TO TABLE IV-2 AND ANNEX TABLES IV-E-6 TO

2. GATE VALVES NOT VERIFIED.

FIGURE IV-2
EXISTING WATER DISTRIBUTION SYS
SAN FERNANDO WATER DISTRICT

System Pressure. Pressures are generally very low throughout the entire distribution system. Table IV-2 is a summary of the recorded 24-hour pressures throughout the system.

Valves and Hydrants. There are 23 known valves in the distribution system in sizes of 75 mm, 100 mm, and 150 mm. A total of 54 fire hydrants are all locally made, and consist of 75-mm GS riser pipes ("wet-barrel") and tees, each with a gate valve and nipple. Most of the hydrants have broken valve stems while others have no valve at all. Twenty of the 54 fire hydrants are not functioning.

Service Connections. As of April 1977, the FER-WD had 1,245 registered connections, all unmetered. The service connections are divided by consumer category into 902 domestic and 343 commercial, with no industrial users. The water system has no public faucets.

Operation and Maintenance

The FER-WD operates and maintains the well sources and the distribution system. Present staffing includes a general manager, an administrative division chief, a production, operation and maintenance division chief, a commercial division chief, a treasurer, an accountant, 2 billing clerks, 12 production operators, 1 service foreman and 1 plumber.

The operation program consists mainly of operating the well pumping stations and filling and emptying the elevated storage tank in Barrio Dolores. The poblacion, Dolores, and Lourdes pump stations are operated 16 hours daily while the Sto. Niño and San Pedro stations are operated daily for 15.5 hours and 12.5 hours, respectively.

The Dolores storage tank is filled from 9:00 p.m. to 3:00 a.m., by the Dolores pump station every fourth day. Water from the tank is released to the distribution system from 1:00 p.m.- 6:00 p.m. on the day of filling.

The maintenance program consists mainly of servicing the pumping units and repairing leaking mains and service lines.

C. WATER QUALITY

Water samples were taken from the present well sources in the poblacion and the nearby barrios. Results of the laboratory analyses of the water samples are listed and compared with the Philippine National Standards for Drinking Water in Table IV-3. The water quality

TABLE IV-1

SUMMARY OF DISTRIBUTION PIPING BY SIZE, MATERIAL AND AGE

Diameter (mm)	Material	Length of Pipe (m)	Year Installed
50	GI	330	No Record
75	GI	5,800	No Record
100	CI	4,550	1929
125	GI	40	1929
150	CI	2,110	1929

TABLE IV-2

24-HOUR PRESSURE RECORDINGS
ON DISTRIBUTION SYSTEM

Number	Fire Hydrant Location[1]	Dated Recorded	Pressure Range	Duration of Pressure Recording (hr)
1	Along Mendoza St. (in front of school)	23-24 May '77	0.07-0.32 kg/sqcm	15
2	Along Tiomico St. (near market)	25-26 May '77	0-0.21 kg/sqcm	23
5	Along Consunji St.	23-24 May '77	0-0.14 kg/sqcm	23
6	Along Capitol Boulevard	21-22 May '77	0.02-0.2 kg/sqcm	24
7	Along Gen. Hizon Ave. cor. Consunji St.	19-20 May '77	0-0.16 kg/sqcm	24
9	Along San Fernando NE Div. Road	24-25 May '77	0.06-0.21 kg/sqcm	24
12	Along Limjoco St.	25-26 May '77	0.07-0.28 kg/sqcm	12
13	Along Arellano St.	24-25 May '77	0.06-0.24 kg/sqcm	24
14	Along Consunji St. (near market	20-21 May '77	0.01-0.19 kg/sqcm	24
15	Bo. Sta. Lucia (near San Pedro Pump Station)	21-22 May '77	0-0.28 kg/sqcm	24

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[1] See Figure IV-2 for location.

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TABLE IV-3

WATER QUALITY TEST RESULTS
SAN FERNANDO WATER DISTRICT

Test	Unit	Permissible Limits	FER-WD Well Poblacion 1 Mar '77	FER-WD Well Bo.Sto. Niño 2 Mar '77	FER-WD Well Bo.San Pedro 2 Mar '77	FER-WD Well Bo. Dolores 3 Mar '77	FER-WD Well Bo. Lourdes 3 Mar '77
Physical							
Color	APHA	15	10	5	10	10	10
Turbidity	FTU	5	3	1.5	1.5	1.5	2
Total Dissolved Solids**	mg/l	500	250	260	276	221	273
Conductivity	micromhos/cm		385	400	425	340	420
Chemical							
pH		7-8.5	7.70	7.80	7.70	7.75	7.80
Total Alkalinity	mg/l CaCO3		140	120	150	120	150
Phenolphthalein	mg/l CaCO3						
Total Hardness	mg/l CaCO3	400***	8	0	8	0	6
Calcium	mg/l	75	2.4	0	0.8	0	1.6
Magnesium	mg/l	50	0.48	0	1.44	0	0.48
Total Iron	mg/l Fe	0.3	0.050	0.020	0.530*	0.025	0.070
Fluoride	mg/l F	1.5	0.50	0.50	0.50	0.50	0.50
Chloride	mg/l	200	12.81	15.25	15.25	7.32	15.25
Sulfate	mg/l	200	25.84	38.08	39.44	25.16	29.92
Nitrate	mg/l	50	10.3	9.8	9.7	10.4	9.9
Manganese	mg/l Mn	0.1	0	nil	nil	nil	nil

* Exceeds the permissible limits set by the Philippine National Standards for Drinking Water, but less than the "excessive" limit established by the standards.

** Computed as 65% of conductivity.

*** Limit inferred from limits of individual metals causing hardness.

of the present sources appears to be within the permissible limits, except the iron content[2] in the San Pedro well.

D. WATER USE PROFILE

General

The current water demands of San Fernando have been analyzed in order to predict future water requirements. Data on revenue produced from the sale of water were obtained from the water district. Other data were taken from field measurements on water production and from the pilot area study[3] conducted in March 1977.

A pilot area was selected within the present service area where a survey was made to establish the present water use profile. Household members in the pilot area were interviewed concerning their source of water supply, number of hours water is available, approximate daily or monthly water consumption, amount paid to the water district per month, number of neighbors using water (borrowers) and number of faucets. The number of persons for each household, the family income bracket and the amount each household is willing to pay for improved water service were also determined. The summary of the pilot area study is presented in Annex IV-D.

Population Served

The pilot area survey indicates that users of the FER-WD water supply can be classified generally into primary users (consumers residing in the home of a registered concessionaire), and secondary users (non-resident consumers obtaining water from registered concessionaires). The secondary users are also termed "borrowers." From the pilot area survey, it is estimated that approximately 9,170 persons are entirely dependent on the FER-WD for water supply, from 1,245 registered service connections. These figures indicate that for every connection an average of 7.36 persons are served, 7.0 as primary users and 0.36 as secondary users.

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[2] These limits are based not upon physiological considerations, for iron in trace amounts is essential for nutrition. Drinking water containing iron in unpalatable and unaesthetic concentrations would have little effect on the total daily intake. Instead of physiological reasons, therefore, the limit is based on aesthetic and taste considerations. Iron tends to precipitate as hydroxides and stains laundry and porcelain fixtures.

[3] See Methodology Memoranda No. 1 and 2.

Water Consumption

Water consumption in the FER-WD was calculated on the basis of pilot area study data and information on the existing water supply system. The average water consumption of concessionaires in the pilot area is about 15.3 cum/mo per household. The consumption of borrowers from the water system is about 8.4 cum/mo per household.

The total consumption of all registered concessionaires is about 19,100 cum/mo while consumption of borrowers is about 550 cum/mo. Since all registered connections are flat-rate, it is assumed that consumption figures obtained in the pilot area survey do not include wastage at flat-rate connections.

Total production of the existing deep well sources was estimated in May 1977 to be 3,980 cumd. Accounted-for-water is only 16 percent of total production. Assuming wastage as 40 percent of the total production and leakage as 25 percent[a], present water accountability in the FER-WD is summarized as follows:

			% of Production
Flat-rate consumption	73 lpcd	635 cumd	16
Borrowers	40 lpcd	20 cumd	0.50
Underestimated flat-rate use	68 lpcd	455 cumd	11.5
Wastage	206 lpcd	1,595 cumd	40.0
Leakage	129 lpcd	995 cumd	25.0
Other uses	36 lpcd	280 cumd	7.0
Total Production		3,980 cumd	100%

E. HYDRAULIC SURVEY DATA

Field measurements of the hydraulic conditions of the FER-WD system were conducted during the period 12-27 May 1977. The purpose of the field measurements is to provide data for a computer model of the existing system and to identify areas with major operational problems.

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[a] Water accountability for the First Ten Provincial Urban Areas indicates that the weighted composites for the different categories of water use are as follows: accounted-for-water, 31 percent of production; underestimated flat-rate use, 11 percent; wastage, 26 percent; leakage, 25 percent; and other uses, 7 percent.

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Pump Stations

Pump tests were conducted at pump stations no. 1, 2, 3, 4, and 5 to determine the head-capacity and efficiency curves for existing pumps (see Annex Figures IV-E-1 through IV-E-5). From these pump curves, the estimated production as of May 1977 was 3,980 cumd. Annex Tables IV-E-1 through IV-E-5 show the recorded test data obtained.

Pump no. 1 as tested has a very low operating efficiency, only about 18 percent as shown in Annex Figure IV-E-1. The pump was severely vibrating due to shaft misalignment, causing damage to the gear head packing. Entrained air was sometimes observed as a result of pumping water level exceeding pump setting.

The operating efficiencies of pumps no. 2 and 4 as tested on 14 May 1977 (Annex Figure IV-E-2) and 16 May 1977 (Annex Figure IV-E-4), were very low. The reason is very low system pressures throughout the distribution lines. Both pumps were operating against very low discharge heads.

Pump no. 3 has a maximum efficiency of about 42 percent. It was operating at this efficiency when tested on 14 May 1977 (see Annex Figure IV-E-3). The FER-WD reportedly had one bowl of this pump removed as it was rubbing against the inner surface of the slanted well casing.

Efficiency curve for pump no. 5 could not be made since it is driven by a diesel engine. Pump speed as measured was 1,160 rpm, much lower than its rated speed of 1,760 rpm. Its concrete foundation had been damaged and has risen about 20 cm above the pumphouse floor level, probably contributing to the excessive vibration observed.

System Pressures

Two pressure recorders were installed at existing pump stations and at various hydrants in the distribution system to determine system pressure variation over a 24-hour period.

Pressures varied from zero to 0.66 kg/sqcm at pump station no. 1 on 18-19 May. Pressures at pump stations no. 2 and 4 ranged (14-15 May) from zero to 0.41 kg/sqcm and from zero to 0.64 kg/sqcm, respectively. Pressures at pump station no. 3 varied from zero to 0.81 kg/sqcm (16-17 May) while those at pump station no. 5 ranged from zero to 1.23 kg/sqcm (19-20 May). The pressure tests at 6 different locations within the distribution system show that pressures generally varied from zero to 0.28 kg/sqcm over 24 hours, indicating very low service pressures throughout the distribution system. Minimum pressures occurred in the evening and early morning after all the pump stations

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were shut off. Annex Figures IV-E-6 through IV-E-16 show the recorded 24-hour pressures in the system.

Hydrant Flow Tests

Hydrant flow tests were conducted to determine how the San Fernando distribution system operated under certain measured flow conditions. Flows from fire hydrants no. 4, 6, 10, and 12 were measured during separate flow tests while pressures were recorded at other locations in the distribution system. The results of the flow tests are listed in Annex Tables IV-E-6 through IV-E-9. The tests showed that for a given hydrant flow, areas between the pump stations and the hydrant where flow was being considered had expected and acceptable pressure decreases while those areas served by other pump stations at other locations of the distribution system were virtually unaffected. Annex Figures IV-E-17 through IV-E-20 show the location of hydrants where flow measurements were made, and points where system pressures were observed.

F. COMPUTER STUDIES

The purpose of conducting computer studies on the existing distribution system is to duplicate, to the greatest extent practicable, the hydraulic conditions observed in the field. By doing this, it is possible to evaluate the impact of improvements on the existing system.

In order to provide field data for computer studies, there must be a significant positive pressure over the entire distribution system during field tests. There were very little field data gathered in San Fernando for the existing system that could be used for computer modelling, therefore, computer studies on the existing system were not conducted.

Data on existing system were based on visual inspection. Assumptions on conditions of existing pipes were based on engineering judgement. Portions of the existing system that could be utilized in the future were retained and included in the computer studies of the future system.

G. DEFICIENCIES OF THE EXISTING SYSTEM

The present water system and level of service of the FER-WD have many serious deficiencies. Low pressure prevails over the entire distribution system. Service connections are not metered. The existing deepwell pumping facilities operate inefficiently. Leaking pipes laid in polluted drains are a potential source of contamination. There is lack of blow-off valves to drain the distribution system. Water supply is never treated or disinfected. Most of the hydrants have broken valve stems while others have no valves at all.

There is inadequate coverage of the water distribution system, particularly in the subdivisions surrounding the present service area.

Operation and maintenance equipment, tools and spare parts are lacking. There are no plumbing shop, water quality laboratory facilities, or routine water sampling and testing programs.

ANNEX IV-D

PILOT AREA SURVEY

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ANNEX IV-D

TO: L. V. Gutierrez, Jr.

FROM: R. P. Abustan

SUBJECT: Pilot Area Survey of San Fernando Water District

DATE: 25 April 1977

I. General Information

A. The pilot area, about 2.4 hectares, is located west of the municipal hall and covers about 1½ blocks along Abad Santos, V. Tiomico and Consunji Streets.

B. The pilot area survey includes a total of 127 households with a total of 889 occupants. From these figures, the number of persons per household is calculated to be 7.0 and the density, 370 persons per hectare.

II. Survey Results

A. Primary and Secondary Users:

Number of registered households	82
Number of household borrowers from registered households	4
Number of households using private wells	38
Number of borrowers from private wells	3
Total number of households	127

B. Consumption Data As Given In Survey

Flat-rate concessionaires	73 lpcd
With private systems	66 lpcd
Borrowers	40 lpcd

C. Willing To Pay For Improved Service/Mo

Below average	=	₱17.33	(3 households)
Middle	=	21.25	(4 ")
Upper middle	=	21.31	(13 ")
High income	=	24.07	(57 ")

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D. Others

1. Average number of faucets per household 3.2
2. Number of connected households with wells 6
3. Number of households with showers 60
4. Number of households with flush water closet 48
5. Number of households with manual water closet 33
6. Number of households with septic tanks 85

III. Computations

A. Total Monthly Production = 3,980 cumd (@ 16 hours operation)
=117,400 cum/mo

B. Number of Connections (flat-rate) = 1,245
Consumption (Connected Households) = 73 lpcd

C. Total Households = 127
Persons/Household = 7
Total Number of Connected Households = 82
Household Borrowers from Connected Households = 4

Total Dependent on System = 86

$$\frac{\text{Total Households Connected}}{\text{Total Dependent on System}} = \frac{82}{86} = 0.95$$

D. Total Households Dependent on System

$$= \frac{1,245}{0.95} = 1,310 \text{ Households or } 9,170 \text{ Persons}$$

Total Borrowers from Connected Households = 1,310 - 1,245
= 65 Households

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ANNEX IV-E

HYDRAULIC SURVEY DATA

ANNEX TABLE IV-E-1

TEST DATA AT PUMP STATION NO. 1

Q (lps)	P (m)	PWL (m)	TDH[1/] (m)	WHP[2/] (hp)	Line Voltage (volts) V1	V2	V3	V ave	Line Current (amp) I1	I2	I3	I ave	IHP[3/] (hp)	Overall[4/] Efficiency (percent)	Pump[5/] Efficiency (percent)
0	11.5	25.8	38.3	0	215	215	219	216	37	37	34	36	15.35	0	0
2.43	8.8	26.1	35.9	1.15	218	215	219	217	36	37	34	35.7	15.29	7.5	8.4
4.18	6.7	26.0	33.7	1.85	218	232	232	227	35.2	37.5	33.5	35.4	15.86	11.7	13.0
8.40	4.9	26.0	31.9	3.52	219	217	224	220	35	37.4	34	35.5	15.41	22.8	25.4
12.66	3.5	26.0	30.5	5.08	220	220	221	220	35	36.7	34.5	35.4	15.37	33.0	36.7
12.66	3.5	26.0	30.5	5.08	232	232	230	231	36.3	37	33.9	35.7	16.27	31.2	34.7
8.58	4.9	24.2	30.1	3.40	233	232	230	232	34.2	36	33.3	34.5	15.80	21.5	23.9
4.40	6.7	25.5	33.2	1.92	239	235	235	236	35.6	35.9	33.5	35	16.30	11.8	13.1
2.65	8.4	25.8	35.2	1.23	228	230	235	231	34.5	37	34.5	35.3	16.09	7.6	8.5
0.42	11.3	25.6	37.9	0.21	236	235	235	235	35	37	35	35.7	16.56	1.3	1.4
0	11.6	25.7	38.3	0	233	236	236	235	37	37	34.5	36.2	16.79	0	0

1/ TDH = P + PWL + hf ; hf = 1.0 m (assumed)

2/ $WHP = \frac{Q \times TDH}{76}$

3/ $IHP = \frac{V\ ave \times I\ ave \times PF \sqrt{3}}{746}$; PF = 0.85 (assumed)

4/ $\text{Overall Efficiency} = \frac{WHP}{IHP} \times 100$

5/ $\text{Pump Efficiency} = \frac{\text{Overall Efficiency}}{\text{Motor Efficiency}}$; Motor Efficiency = 90% (assumed)

ANNEX TABLE IV-E-2

TEST DATA AT PUMP STATION NO. 2

Q (lps)	P (m)	PWL (m)	TDH[1] (m)	WHP[2] (hp)	Line Voltage (volts) V1	V2	V3	V ave	Line Current (amp) I1	I2	I3	I ave	IHP[3] (hp)	Overall[4] Efficiency (present)	Pump[5] Efficiency (present)
29.2	1.0	17.5	20.0	7.68	225	230	230	228	72	84	80	78.7	35.41	21.7	24.1
28.7	7.0	17.6	26.1	9.86	225	225	230	227	70	84	78	77.3	34.63	28.5	31.6
27.9	14.1	17.5	33.1	12.15	225	225	230	227	72	86	80	79.3	35.52	34.2	38.0
27.1	21.1	17.5	40.1	14.30	225	225	230	227	74	88	82	81.3	36.42	39.3	43.6
26.5	28.2	17.3	47.0	16.39	225	230	230	228	76	88	84	82.6	37.17	44.1	49.0
25.4	35.2	17.2	53.9	18.01	225	225	230	227	78	92	86	85.3	38.4	47.1	52.4
24.9	42.2	17.2	60.9	19.95	225	225	230	227	78	92	86	85.3	38.21	52.2	58.0
23.6	49.3	17.0	67.8	21.05	225	225	230	227	78	92	88	86	38.53	54.6	60.7
22.4	56.3	16.8	74.6	21.98	225	230	235	230	78	92	88	86	39.04	56.3	62.2
21.3	63.4	16.7	81.6	22.87	230	230	235	232	80	92	88	86.7	39.70	57.6	64.0
19.2	70.4	16.3	88.2	22.28	228	228	231	229	76	90	84	83.3	37.65	59.2	65.8
18.0	77.4	16.1	95.0	22.50	225	225	230	227	74	88	84	82	36.74	61.2	68.0
15.8	84.5	15.7	101.7	21.14	228	228	232	229	72	86	80	79.3	35.84	59.0	65.5
13.1	91.5	15.3	108.3	18.67	228	228	232	229	70	84	78	77.3	34.93	53.4	59.4
10.3	98.6	14.9	115.0	15.58	230	230	235	232	66	78	74	72.7	33.29	46.8	52.0
7.7	105.6	14.6	121.7	12.33	230	230	225	228	62	78	72	70.7	31.81	38.8	43.1

[1] TDH = P + PWL + hf where an assumed hf = 1.5 m is used.

[2] $WHP = \frac{Q \times TDH}{76}$

[3] $IHP = \frac{V_{ave} \times I_{ave} \times \text{Power Factor} \times \sqrt{3}}{746}$ where Power factor = 0.85 (assumed)

[4] $\text{Overall Efficiency} = \frac{WHP}{IHP} \times 100$

[5] $\text{Pump Efficiency} = \frac{\text{Overall Efficiency}}{\text{Motor Efficiency}}$ where an assumed motor efficiency of 90% is used.

ANNEX TABLE IV-E-3

TEST DATA AT PUMP STATION NO. 3

Q (lps)	P (m)	PWL (m)	TDH[1] (m)	WHP[2] (hp)	Line Voltage (volts) V1	V2	V3	V ave	Line Current (amp) I1	I2	I3	I ave	IHP[3] (hp)	Overall[4] Efficiency (percent)	Pump[5] Efficiency (percent)
7.95	1.8	33.1	35.9	3.76	215	205	215	212	25	19.5	26	23.5	9.83	38.2	42.5
7.30	3.5	33.0	37.5	3.60	214	205	212	210	24.5	19	23	22.2	9.20	39.1	43.5
6.45	7.4	31.4	39.8	3.38	215	205	210	210	24	18.5	25.5	22.7	9.41	35.9	39.9
5.60	11.6	29.7	42.3	3.12	215	205	210	210	23	18.5	25.5	22.3	9.24	33.8	37.5
5.00	14.4	28.2	43.6	2.87	215	207	212	211	23.5	18	25.5	22.3	9.28	30.9	34.4
3.85	18.3	26.6	45.9	2.32	215	205	211	210	22.5	17.5	25	21.7	8.99	25.8	28.7
1.88	21.1	22.3	44.4	1.10	215	205	212	211	21	16.5	24	20.5	8.54	12.9	14.3
0	28.2	18.9	48.1	0	215	205	212	211	20	15.5	22.5	19.3	8.04	0	0

1/ $TDH = P + PWL + hf$; $hf = 1.0$ m (assumed)

2/ $WHP = \frac{Q \times TDH}{76}$

3/ $IHP = \frac{V_{ave} \times I_{ave} \times PF \sqrt{3}}{746}$; PF = 0.85 (assumed)

4/ $\text{Overall Efficiency} = \frac{WHP}{IHP} \times 100$

5/ $\text{Pump Efficiency} = \frac{\text{Overall Efficiency}}{\text{Motor Efficiency}}$; Motor Efficiency = 90% (assumed)

ANNEX TABLE IV-E-4

TEST DATA AT PUMP STATION NO. 4

Q (lps)	P (m)	PWL (m)	TDH 1/ (m)	WHP 2/ (hp)	Line Voltage (volts) V1	V2	V3	V ave	Line Current (amp) I1	I2	I3	I ave	IHP 3/ (hp)	Overall 4/ Efficiency (percent)	Pump 5/ Efficiency (percent)
20.1	0	20.6	21.6	5.71	225	225	220	223	35.8	32	35.5	34.4	15.14	37.7	41.9
19.2	3.5	21.2	25.7	6.49	220	225	220	222	36.5	32	35.5	34.7	15.20	42.7	47.4
18.2	7.0	21.2	29.2	6.99	220	225	220	222	36.5	32	35.5	34.7	15.20	46.0	51.1
17.0	10.9	20.8	32.8	7.34	223	228	220	224	35	31	34.5	33.5	14.8	49.6	55.1
16.0	14.8	20.3	36.1	7.60	225	230	225	227	34.5	31	34.5	33.3	14.92	50.9	56.6
15.0	17.6	20.0	38.6	7.62	228	231	228	229	35	31	34	33.3	15.05	50.6	56.2
13.9	20.8	19.3	41.1	7.52	230	230	225	228	34	30	33	32.3	14.53	51.8	57.5
12.4	24.6	18.6	44.2	7.21	230	230	225	228	33	29	32	31.3	14.08	51.2	56.9
10.7	28.9	17.6	47.5	6.69	230	230	220	227	31.5	28	30	29.8	13.35	50.1	55.7
9.1	32.0	16.7	49.7	5.95	228	230	225	228	29.5	26	29.5	28.3	12.73	46.7	51.9
7.6	35.6	15.6	52.2	5.22	230	232	226	229	29	24.5	28	27.2	12.29	42.5	47.2
5.4	39.4	54.9	54.9	3.90	230	233	230	231	27	23.5	26.5	25.7	11.72	33.3	37.0
0	42.2	12.4	55.6	0	230	230	229	229	22.5	20	22.5	21.7	9.81	0	0

1/ TDH = P + PWL + hf ; hf = 1.0 (assumed)

2/ $WHP = \frac{Q \times TDH}{76}$

3/ $IHP = \frac{Vave \times Iave \times PF \times \sqrt{3}}{746}$; PF = 0.85 (assumed)

4/ $\text{Overall Efficiency} = \frac{WHP}{IHP} \times 100$

5/ $\text{Pump Efficiency} = \frac{\text{Overall Efficiency}}{\text{Motor Efficiency}}$; Motor Efficiency = 90% (assumed)

ANNEX TABLE IV-E-5

TEST DATA AT PUMP STATION NO. 5

Q (lps)	P (m)	PWL (m)	TDH[1] (m)	Pump Speed (rpm)
13.2	3.03	19.49	23.52	1170
12.2	7.04	19.11	27.15	1160
11.3	10.56	17.93	29.49	1190
9.9	14.08	17.42	32.50	1215
9.1	17.60	16.64	35.24	1270
7.0	21.12	15.53	37.65	1320
5.6	28.16	14.68	43.84	1340
4.8	31.68	13.82	46.50	1355
3.7	35.20	12.37	48.57	1430
0	42.24	11.94	55.18	1315

[1] TDH = P + PWL + hf where an assumed hf = 1.0 m is used.

ANNEX TABLE IV-E-6

DATA ON HYDRANT FLOW TEST NO. 1

Hydrant number	1	2	3	4	
Elevation above ground	37 cm	49 cm	46 cm	Ground Level	
Time (pm)	P_1 (m)	P_2 (m)	P_3 (m)	P_4 (m)	Q_4 (lps)
3:10	2.46	2.25	2.53	3.52	0
3:11	2.11	2.25	2.43	1.27	6.44
3:12	2.39	2.11	2.25	1.27	6.26
3:13	2.29	2.04	2.25	1.27	6.16
3:14	2.29	2.08	2.18	1.27	6.16
3:15	2.29	2.08	2.18	1.27	6.16
3:16	2.29	2.11	2.18	1.27	6.16
3:17	2.11	2.08	2.11	1.27	6.16
3:18	2.11	2.08	1.97	1.27	5.97
3:19	2.25	2.10	2.08	1.27	5.97
3:20	2.46	2.18	2.15	1.27	5.97

ANNEX TABLE IV-E-7

DATA ON HYDRANT FLOW TEST NO. 2

Hydrant Number	4	5	6	
Elevation above ground	Ground Level	33 cm	60 cm	
Time (pm)	P_4 (m)	P_5 (m)	P_6 (m)	Q_6 (lps)
4:20	3.31	1.55	1.55	0
4:21	3.03	1.27	0	1.71
4:22	2.96	1.27	0	1.46
4:23	2.89	1.41	0	1.40
4:24	2.89	1.41	0	1.43
4:25	2.89	1.41	0	0.94
4:26	2.89	1.41	0	0.82
4:27	2.89	1.41	0	0.85

Note:

An automatic pressure recorder installed at hydrant No. 7 showed a pressure drop of about 0.14 m during the test (from 0.98 to 0.84 m).

ANNEX TABLE IV-E-8

DATA ON HYDRANT FLOW TEST NO. 3

Hydrant Number	8	10	
Elevation Above Ground	60 cm	110 cm	
Time (pm)	P_8 (m)	P_{10} (m)	Q_{10} (lps)
2:05	5.07	1.23	0
2.06	4.93	0	1.33
2.07	5.07	0	1.43
2:08	5.28	0	1.57
2:09	5.28	0	1.56
2:10	5.00	0	1.65
2:11	5.14	0	1.56
2:12	5.07	0	1.46
2:13	5.07	0	1.53
2:14	5.21	0	1.50
2:15	5.14	0	1.60
2:16	5.14	0	1.47
2:17	5.35	0	1.72
2:18	5.63	0	1.66
2.19	5.63	0	1.66
2.20	5.63	0	1.75

Note:

An automatic pressure recorder installed at hydrant No. 9 showed a pressure drop of about 0.56 m (from 3.52 m to 2.96 m).

ANNEX TABLE IV-E-9

DATA ON HYDRANT FLOW TEST NO. 4

Hydrant Number	11	12	
Elevation Above Ground	30 cm	40 cm	
Time (pm)	P_{11} (m)	P_{12} (m)	Q_{12} (lps)
3:40	2.82	2.25	0
3:41	1.97	0	3.00
3:42	1.97	0	3.16
3.43	1.97	0	3.41
3:44	1.97	0	3.41
3:45	1.97	0	3.24
3.46	1.97	0	3.00

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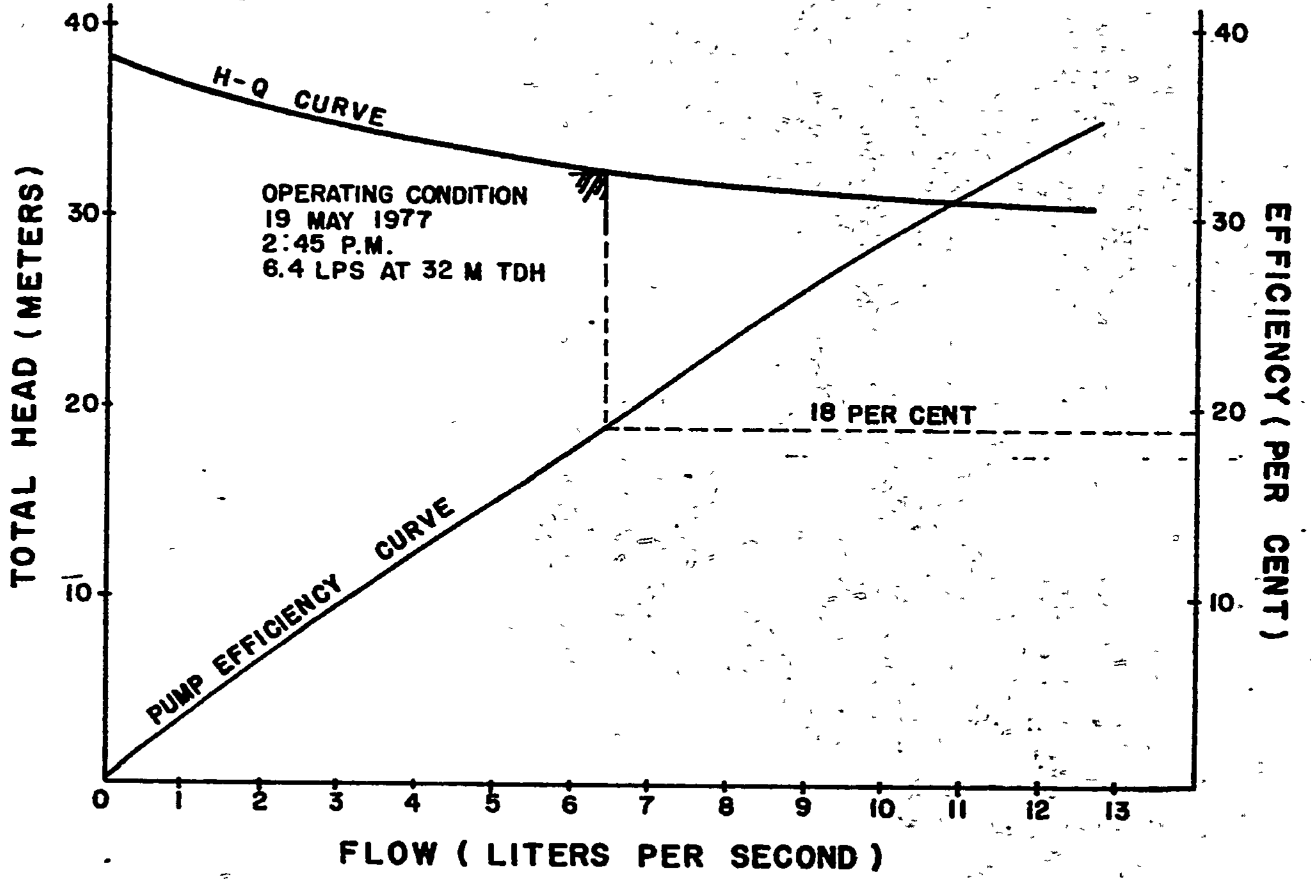
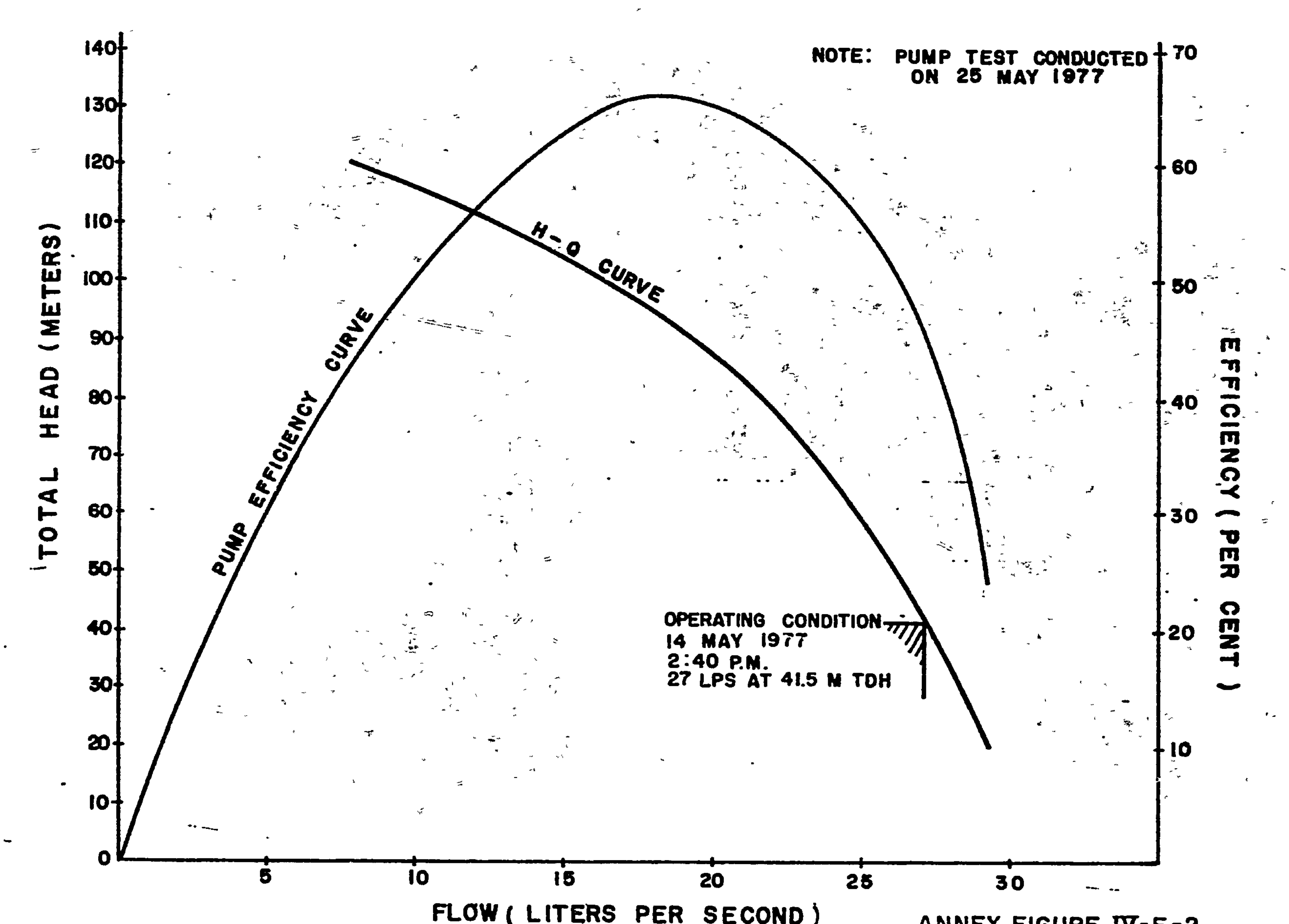
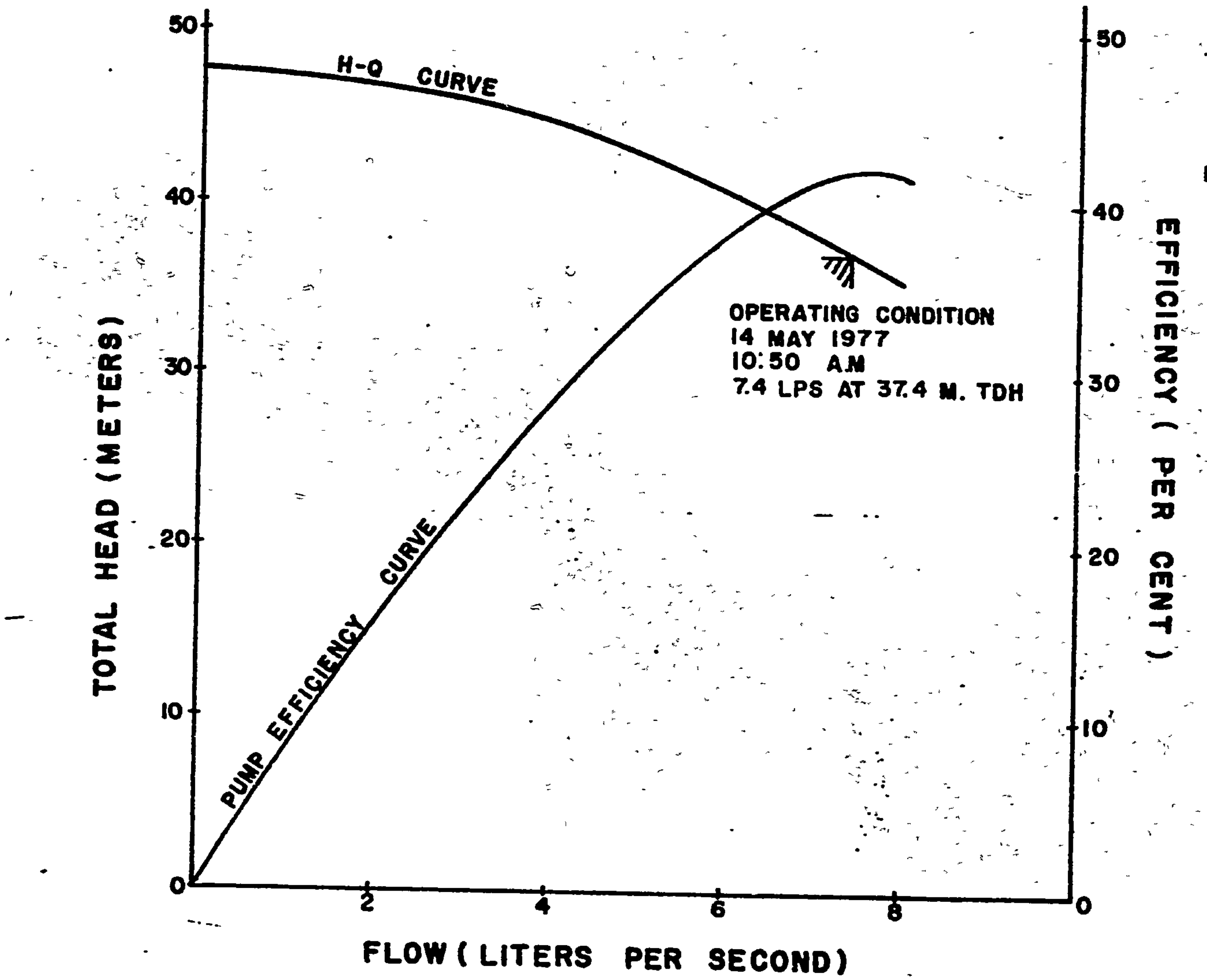


NOTE: PUMP TEST CONDUCTED ON 19 MAY 1977

ANNEX FIGURE IV-E-1
PUMP PERFORMANCE CURVE
AT PUMP STATION NO.1
SAN FERNANDO WATER DISTRICT



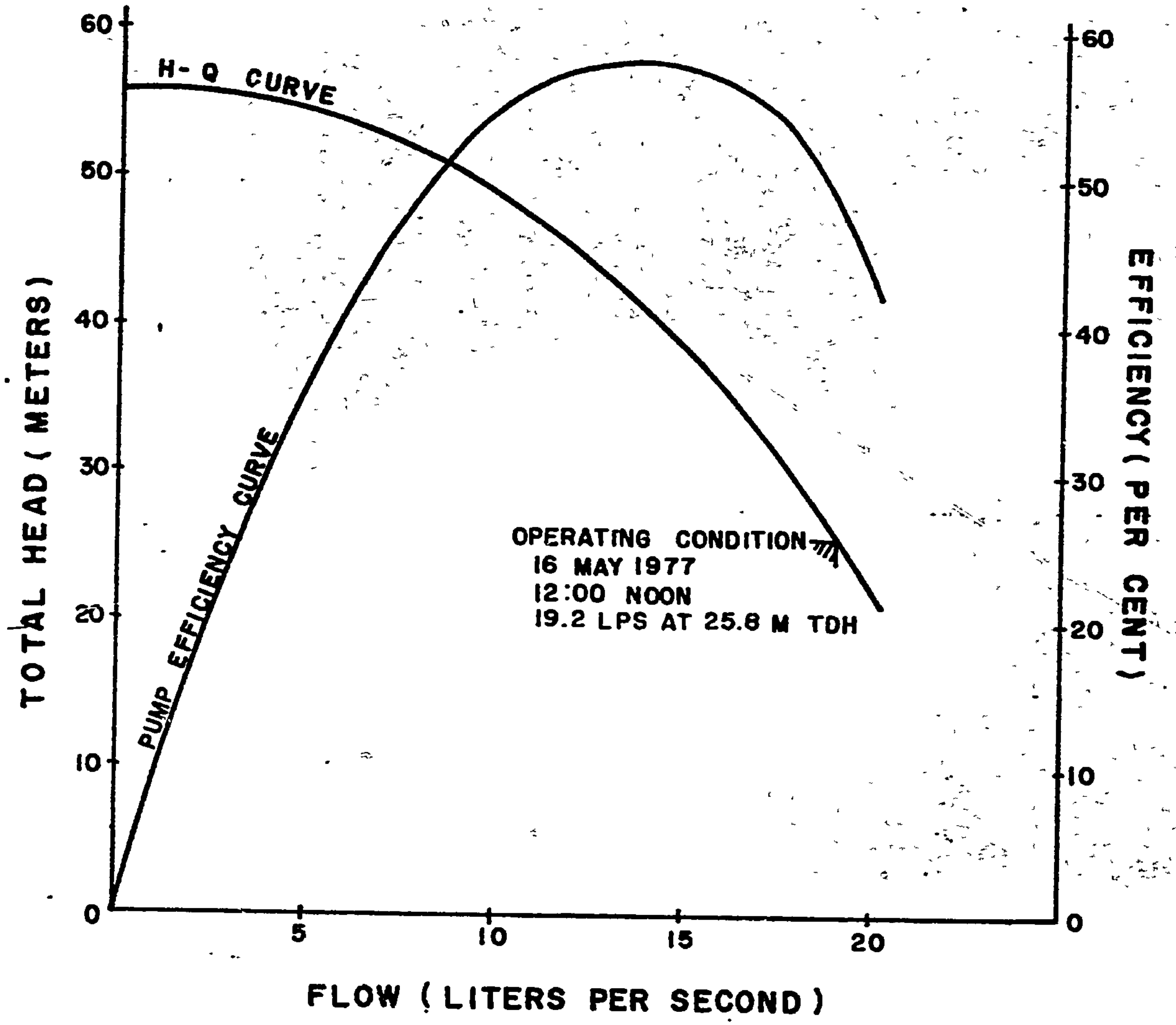
ANNEX FIGURE IV-E-2
PUMP PERFORMANCE CURVE
AT PUMP STATION NO.2
SAN FERNANDO WATER DISTRICT



NOTE: PUMP TEST CONDUCTED ON 19 MAY 1977

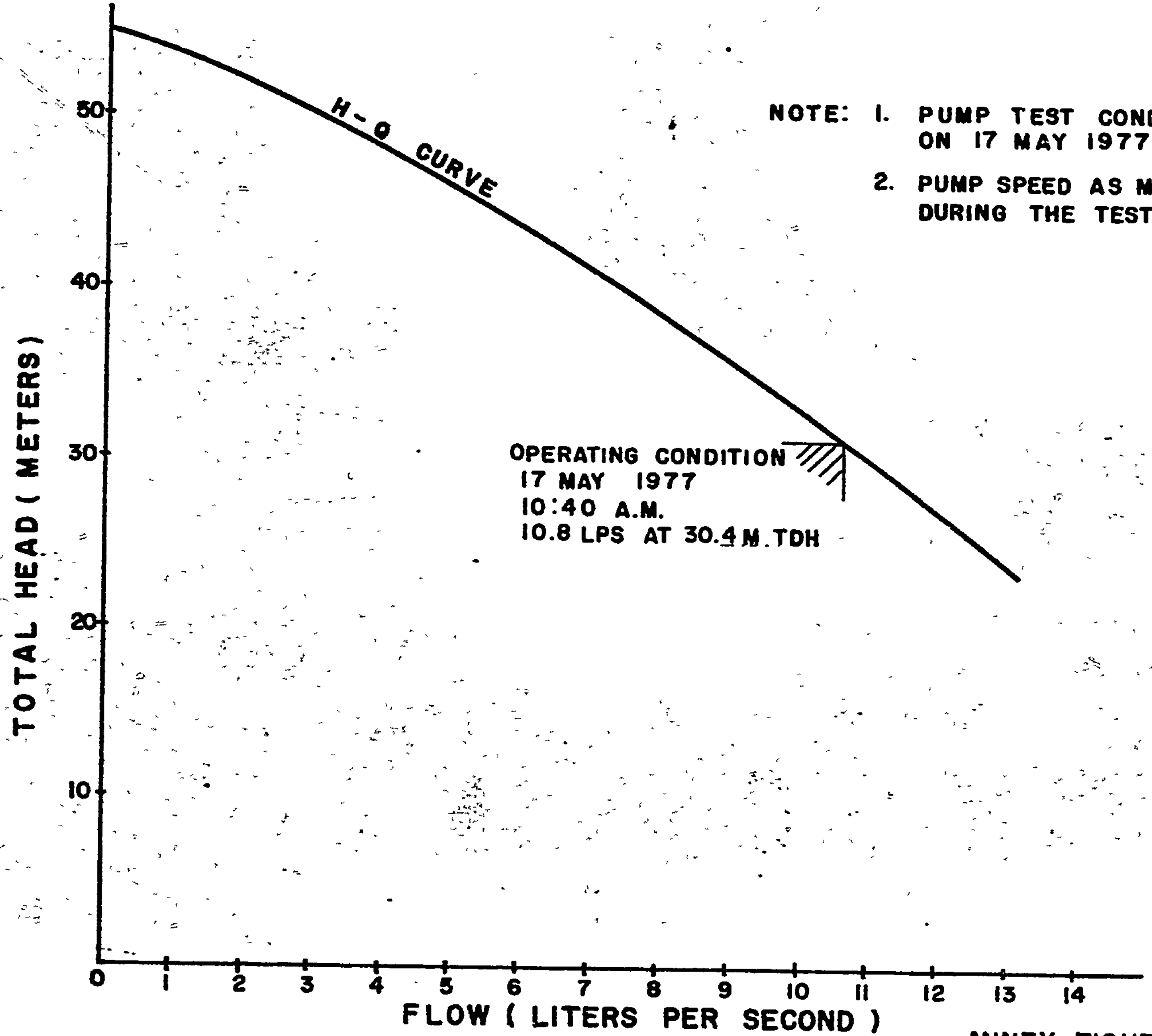
FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

ANNEX FIGURE IV-E-3
PUMP PERFORMANCE CURVE
AT PUMP STATION NO.3
SAN FERNANDO WATER DISTRICT

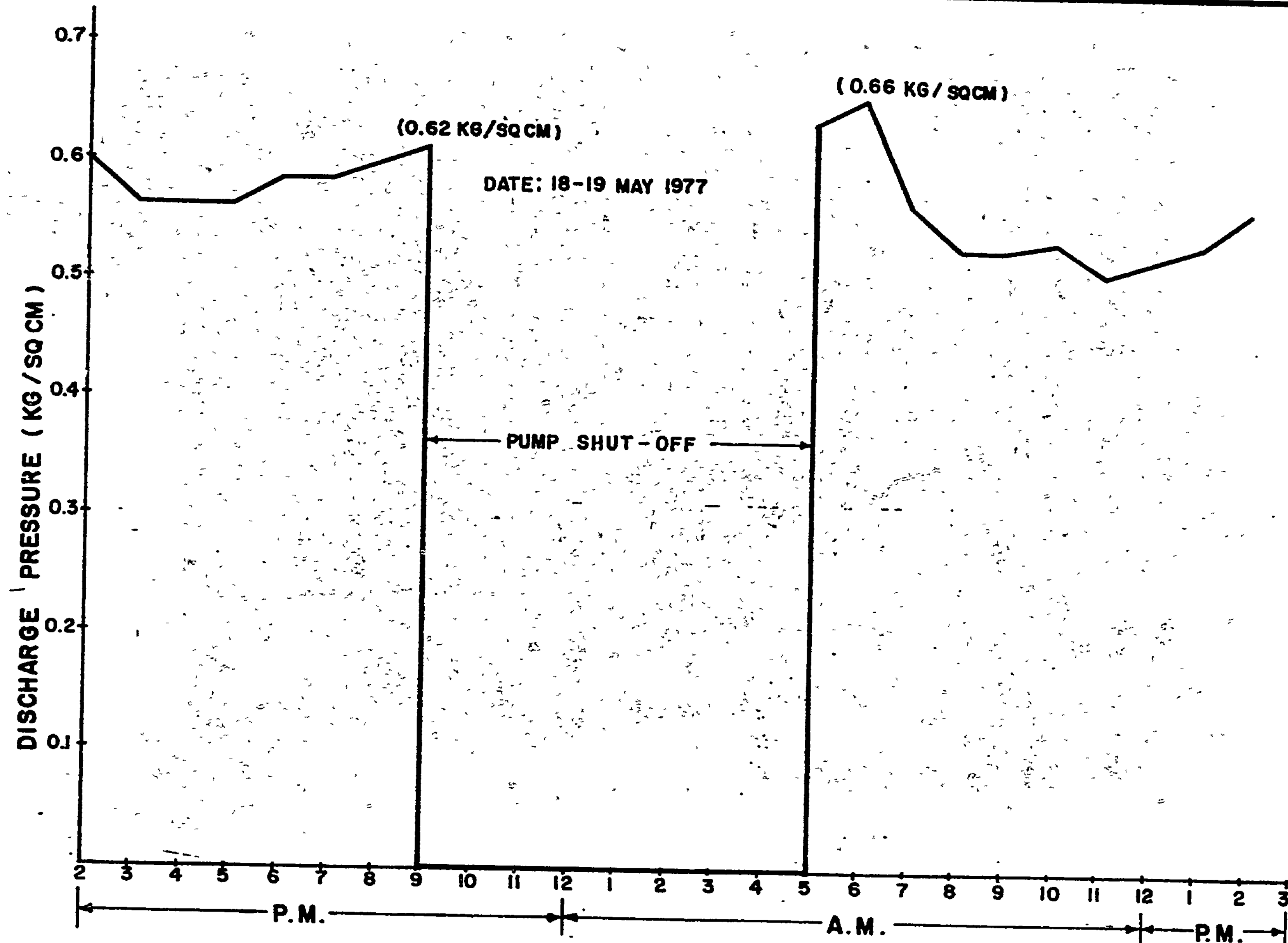


NOTE: PUMP TEST CONDUCTED ON 23 MAY 1977

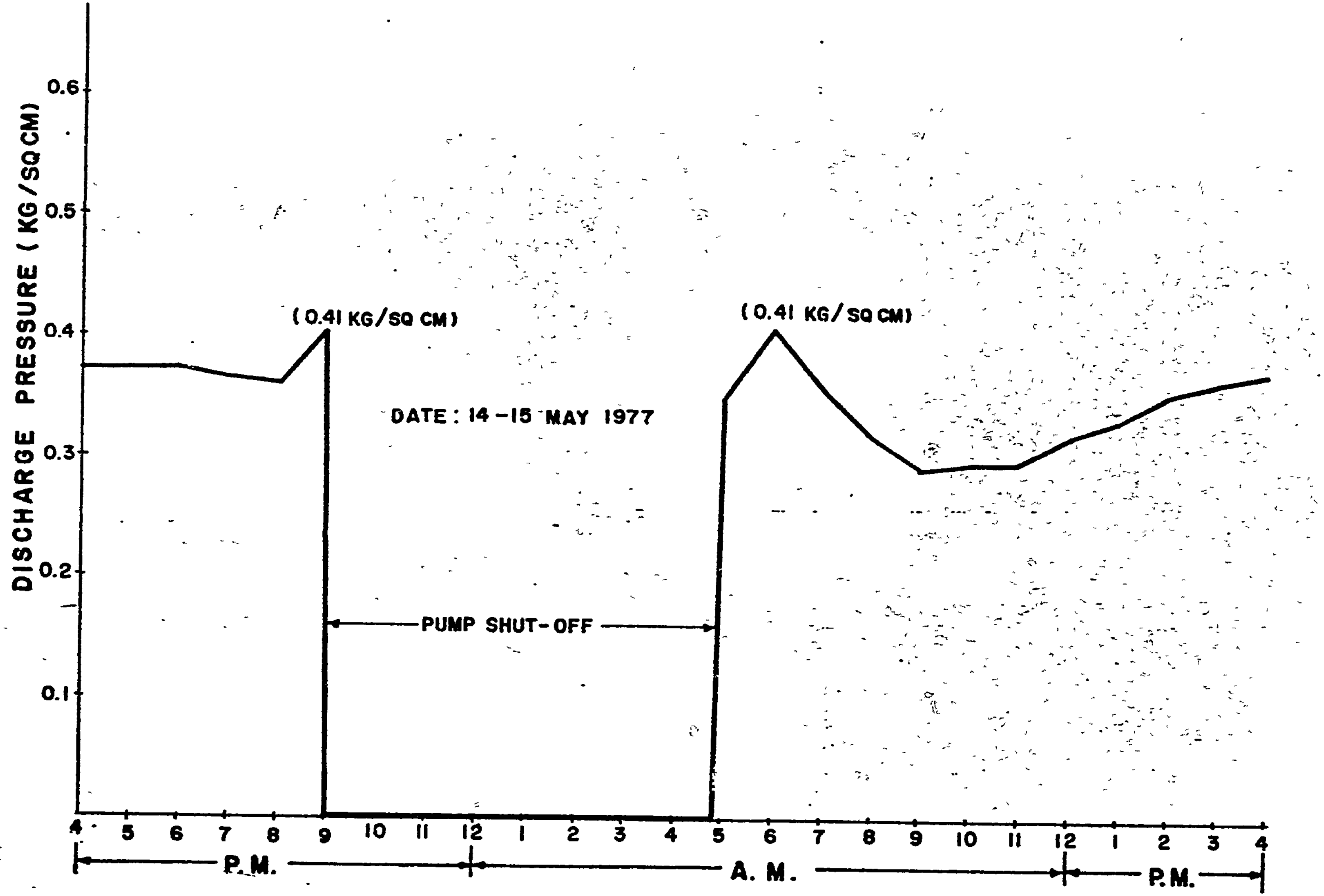
ANNEX FIGURE IV-E-4
PUMP PERFORMANCE CURVE
AT PUMP STATION NO.4
SAN FERNANDO WATER DISTRICT



ANNEX FIGURE IV-E-5
PUMP PERFORMANCE CURVE
AT PUMP STATION NO.5
SAN FERNANDO WATER DISTRICT

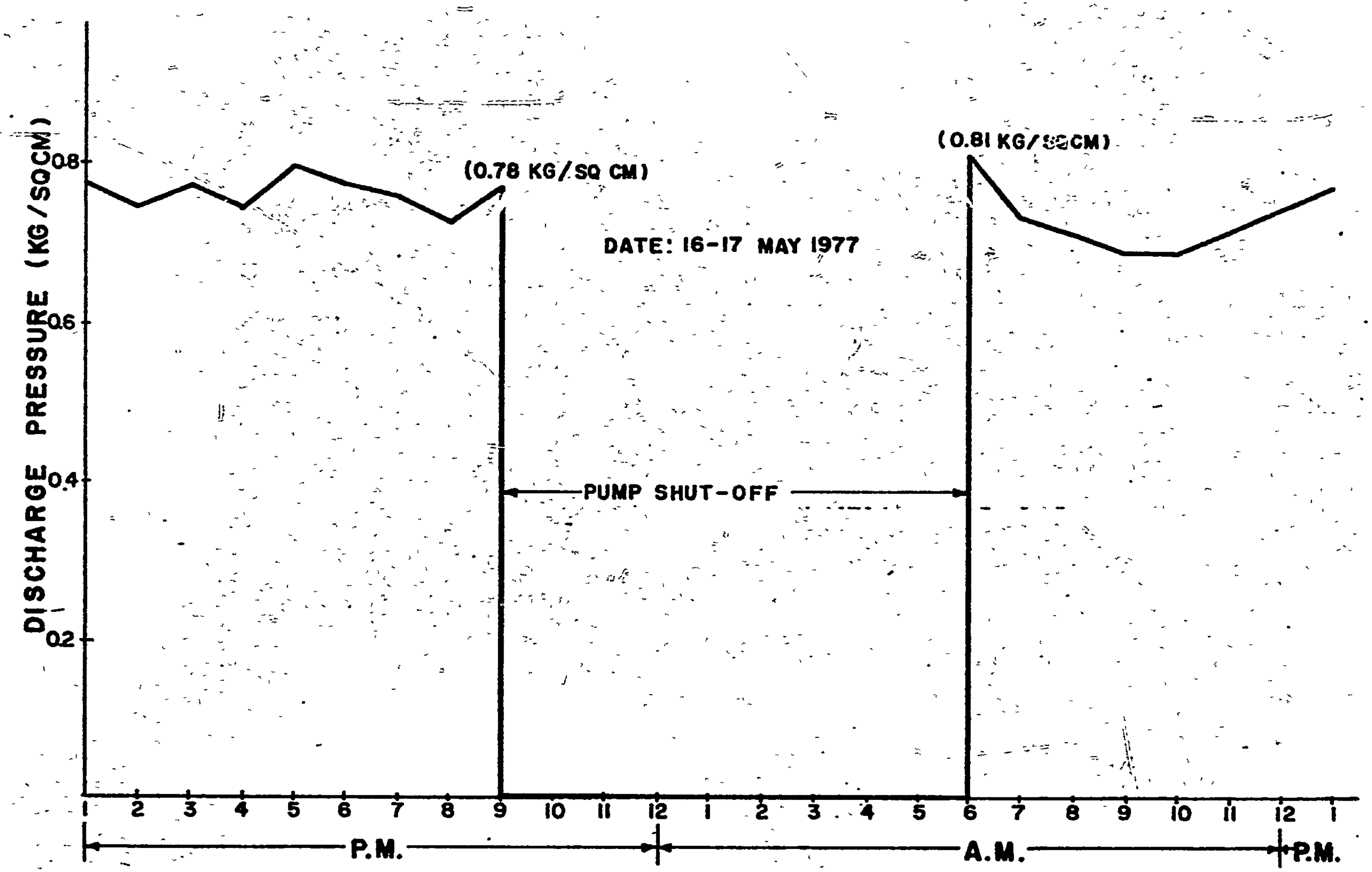


ANNEX FIGURE IV-E-6
24 HOUR DISCHARGE PRESSURE
AT PUMP STATION NO. I
SAN FERNANDO WATER DISTRICT

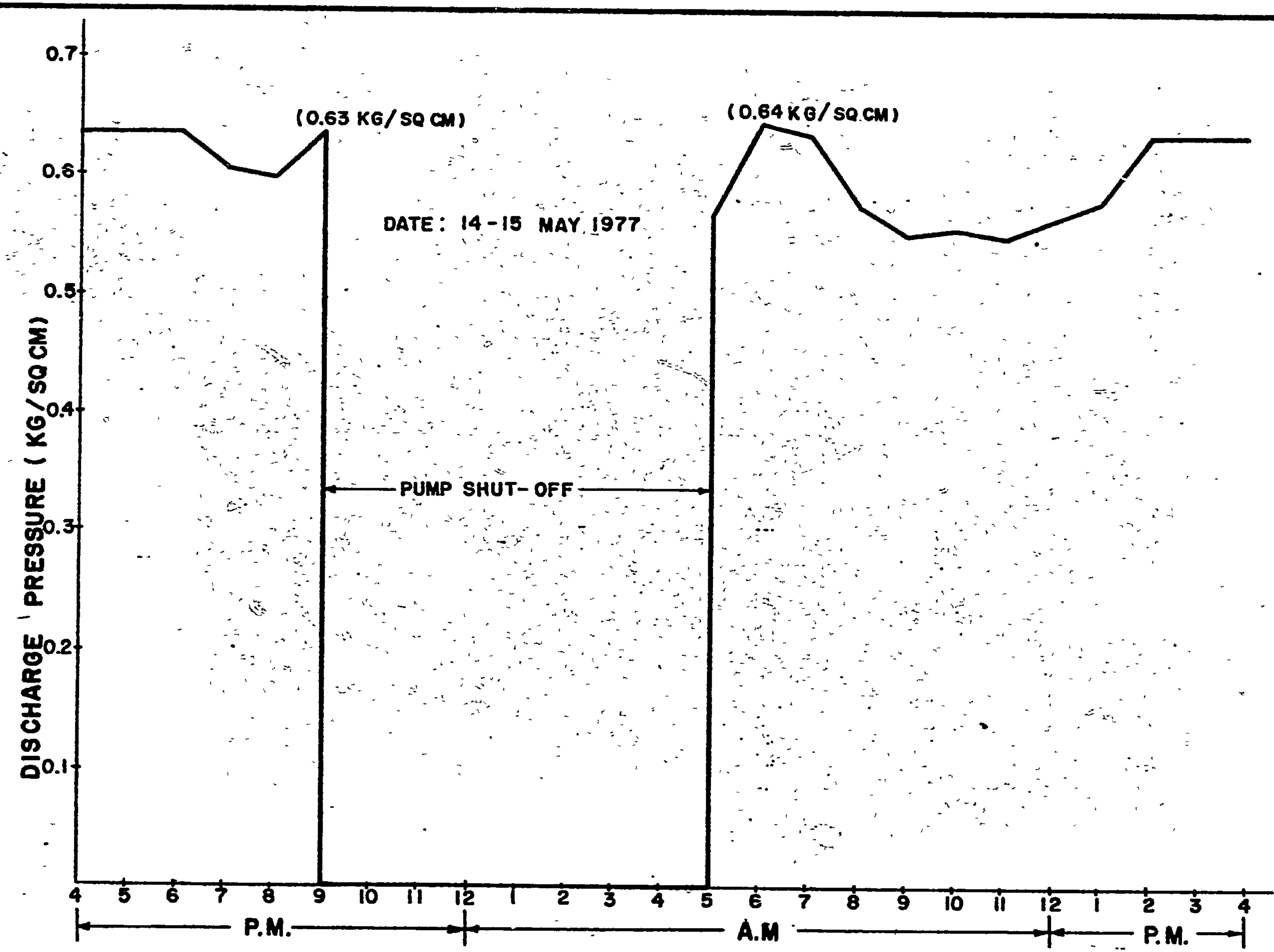


ANNEX FIGURE IV-E-7
24 HOUR DISCHARGE PRESSURE
AT PUMP STATION NO. 2
SAN FERNANDO WATER DISTRICT

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM



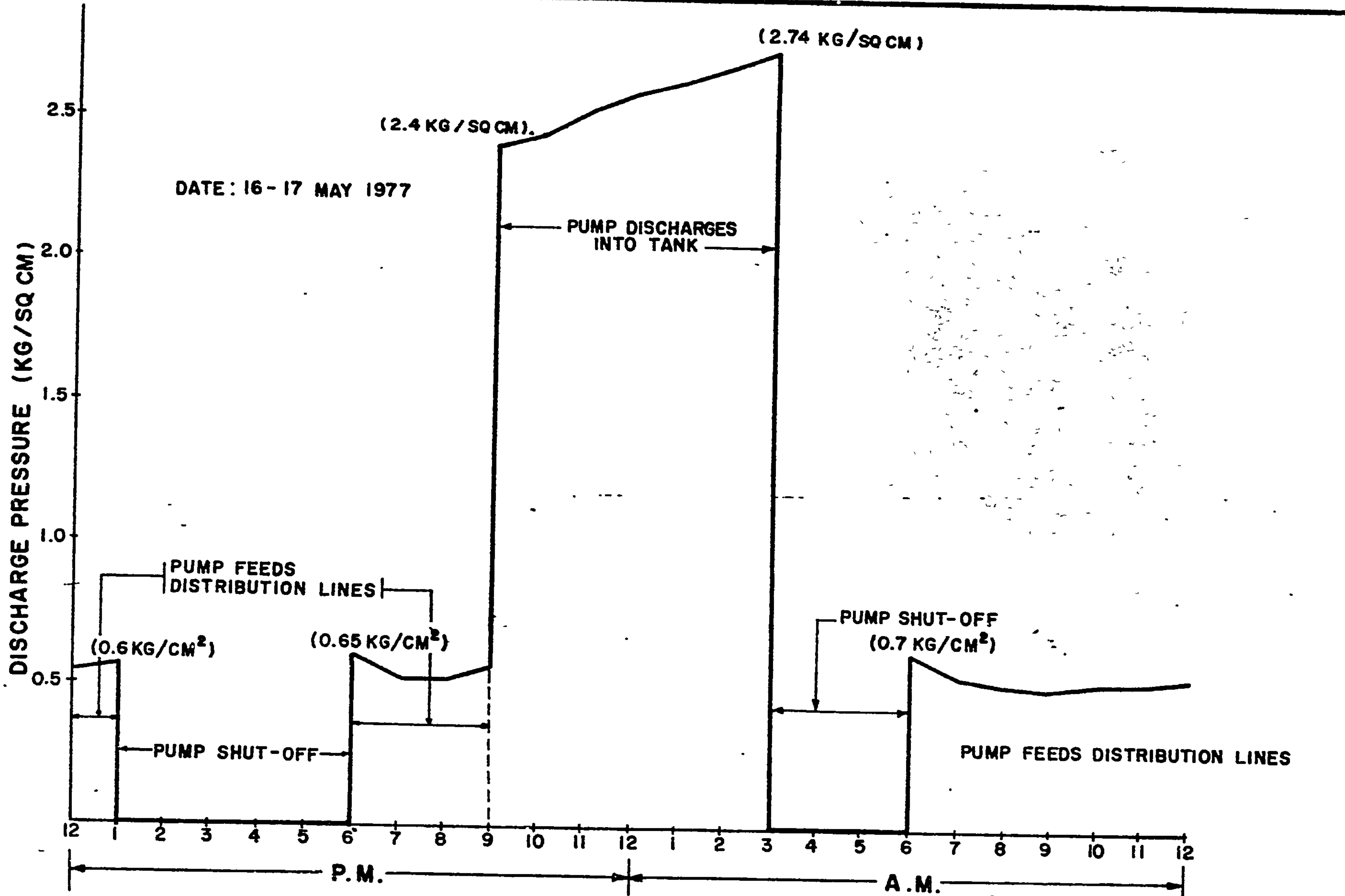
ANNEX FIGURE IV-E-8
24 HOUR DISCHARGE PRESSURE
AT PUMP STATION NO.3
SAN FERNANDO WATER DISTRICT



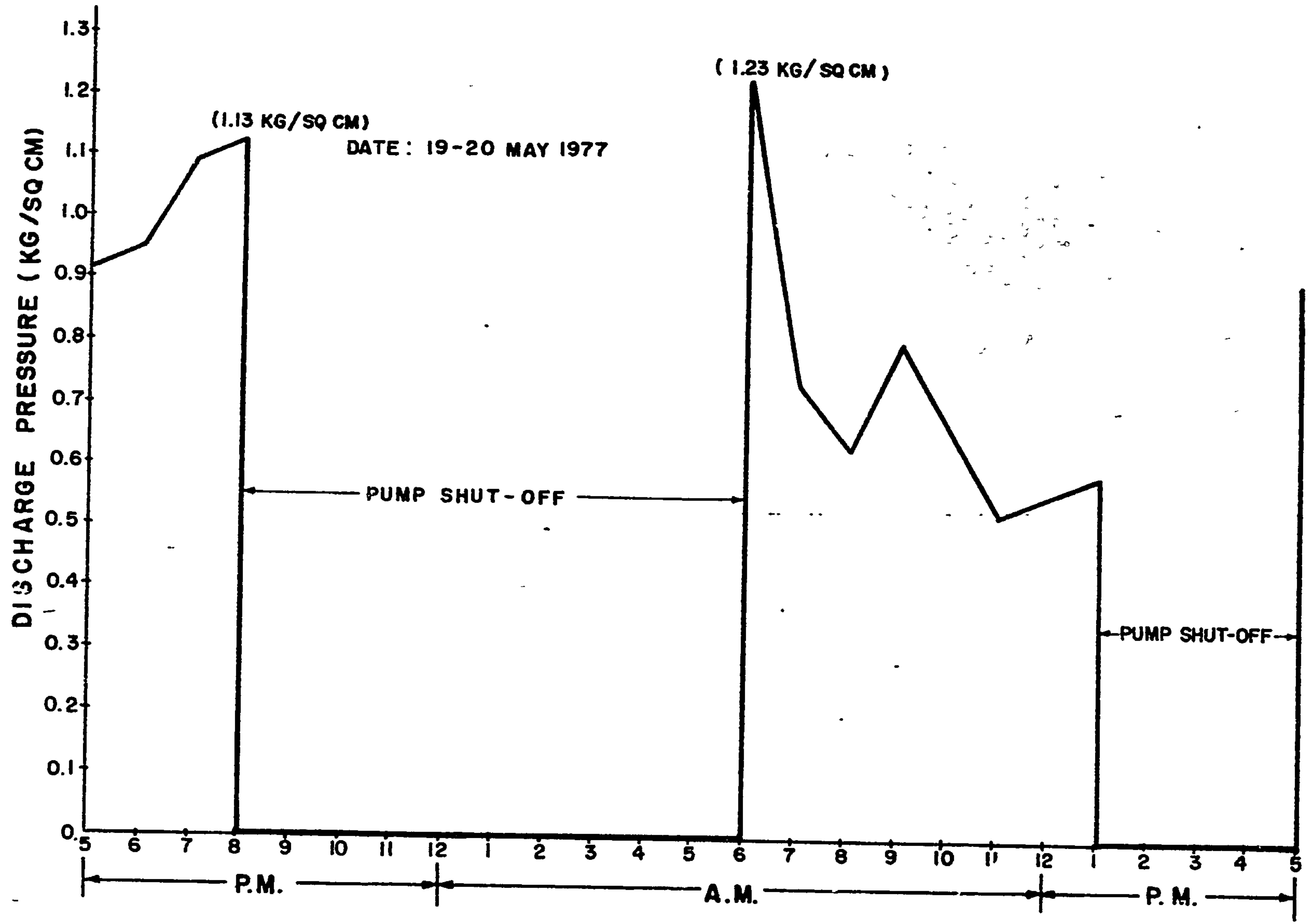
ANNEX FIGURE IV-E-9a
24 HOUR DISCHARGE PRESSURE
AT PUMP STATION NO.4
SAN FERNANDO WATER DISTRICT

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS

LWUA-CDM

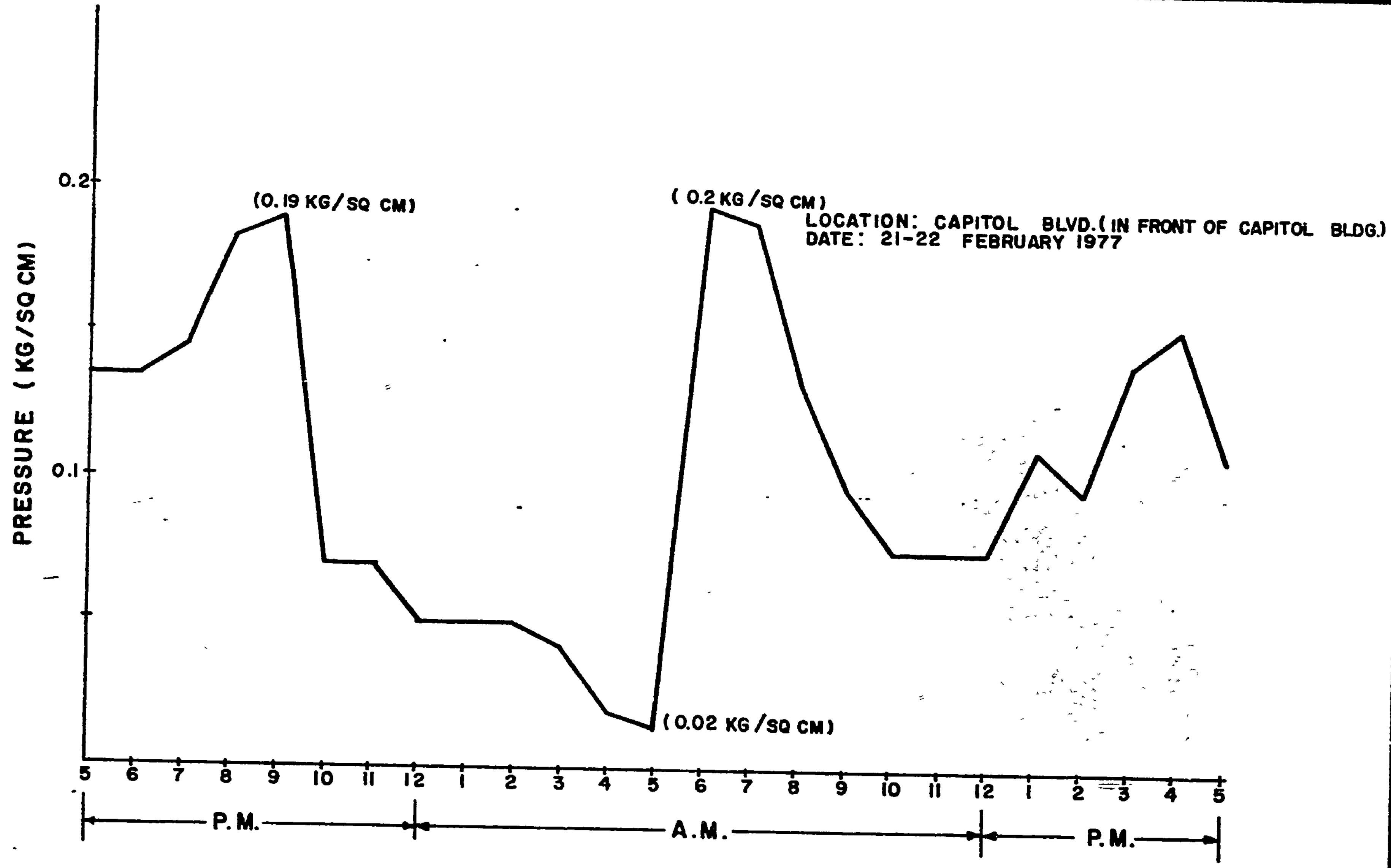


ANNEX FIGURE IV-E-9b
24 HOUR DISCHARGE PRESSURE
AT PUMP STATION NO. 4
SAN FERNANDO WATER DISTRICT

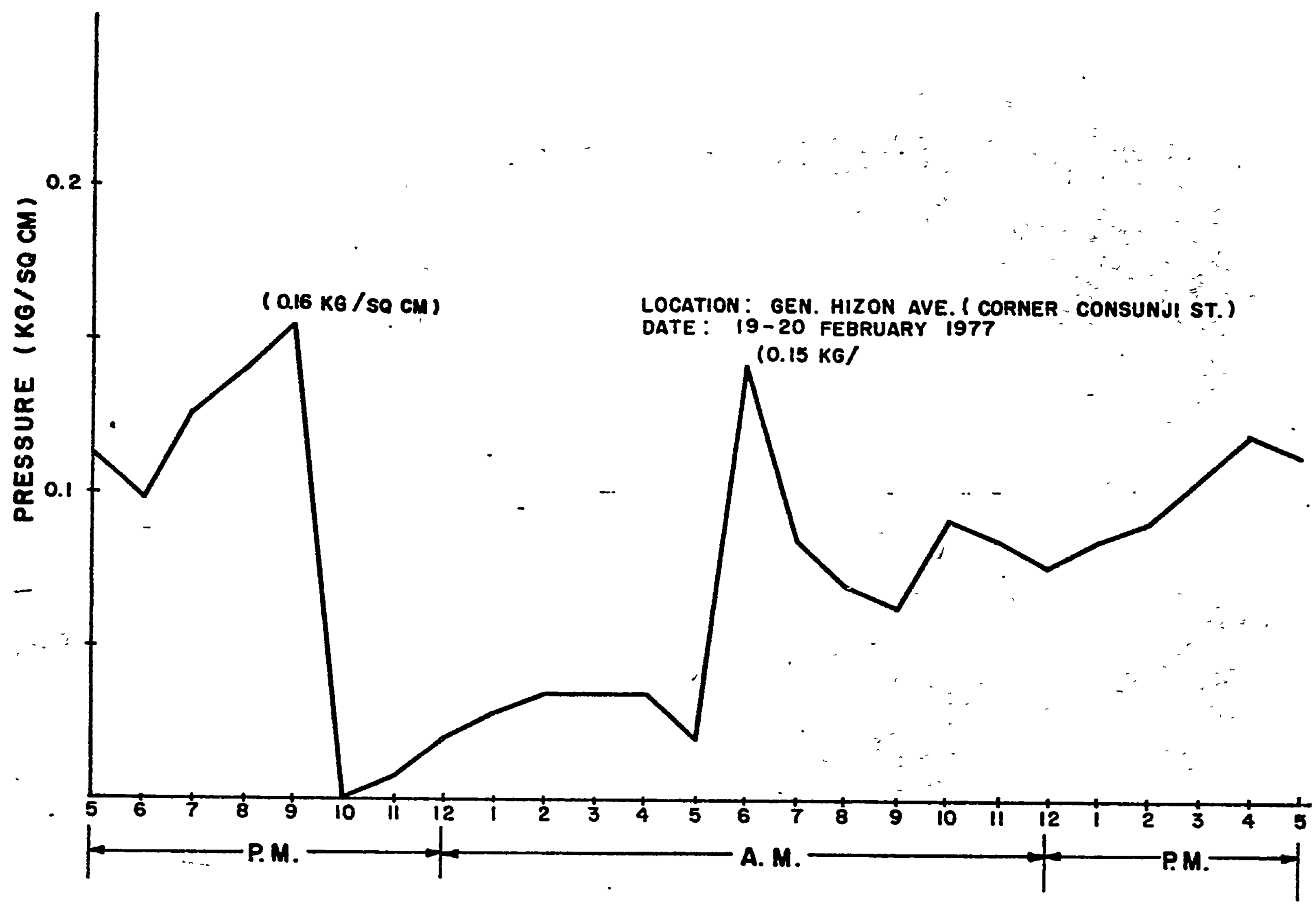


FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

ANNEX FIGURE IV-E-10
24 HOUR DISCHARGE PRESSURE AT PUMP STATION NO.5
SAN FERNANDO WATER DISTRICT

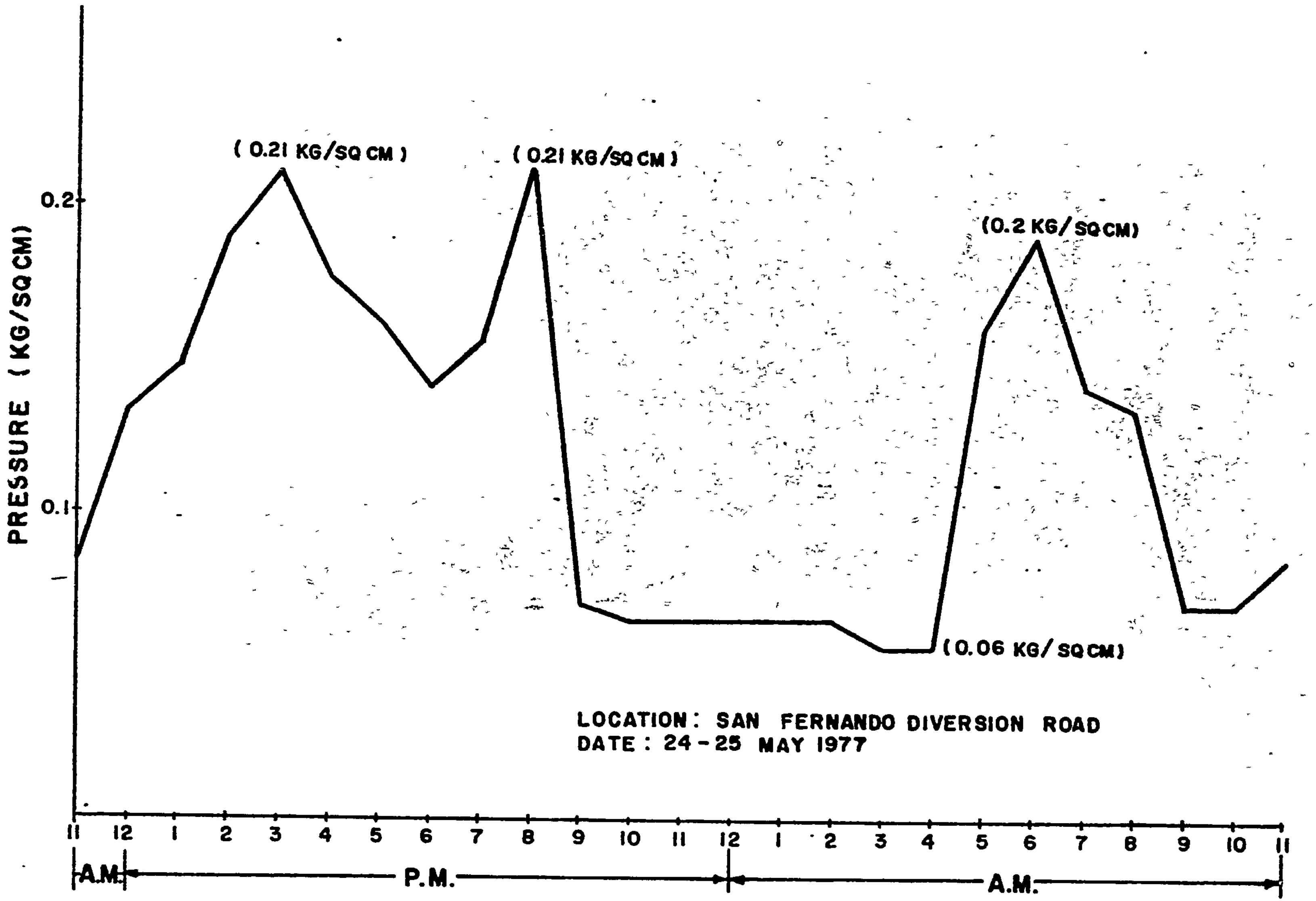


ANNEX FIGURE IV-E-11
24 HOUR SYSTEM PRESSURE AT FIRE HYDRANT NO. 6
SAN FERNANDO WATER DISTRICT



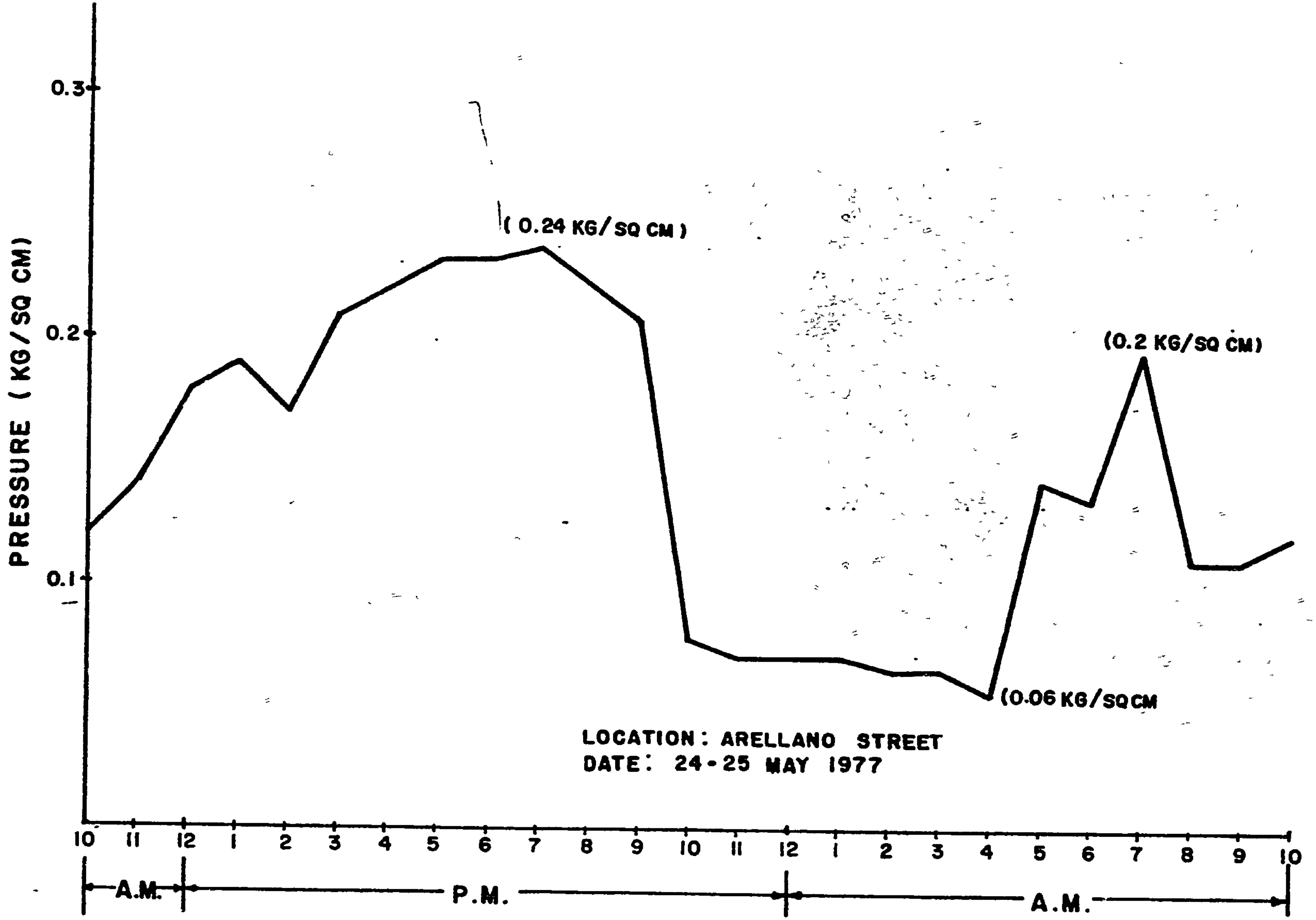
ANNEX FIGURE IV-E-12
24 HOUR SYSTEM PRESSURE
AT FIRE HYDRANT NO. 7
SAN FERNANDO WATER DISTRICT

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM



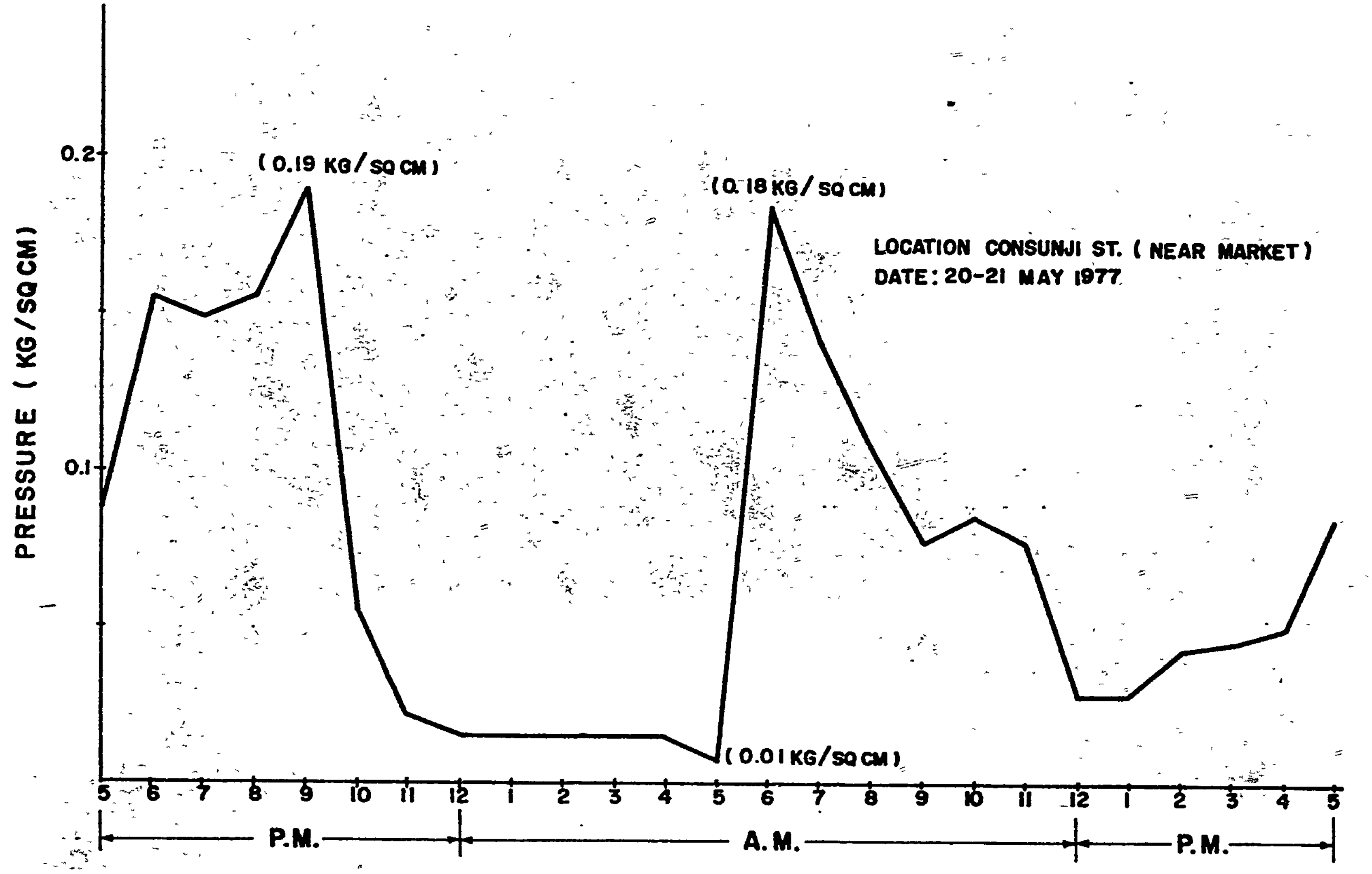
ANNEX FIGURE IV-E-13
24 HOUR SYSTEM PRESSURE
AT FIRE HYDRANT NO. 9
SAN FERNANDO WATER DISTRICT

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM



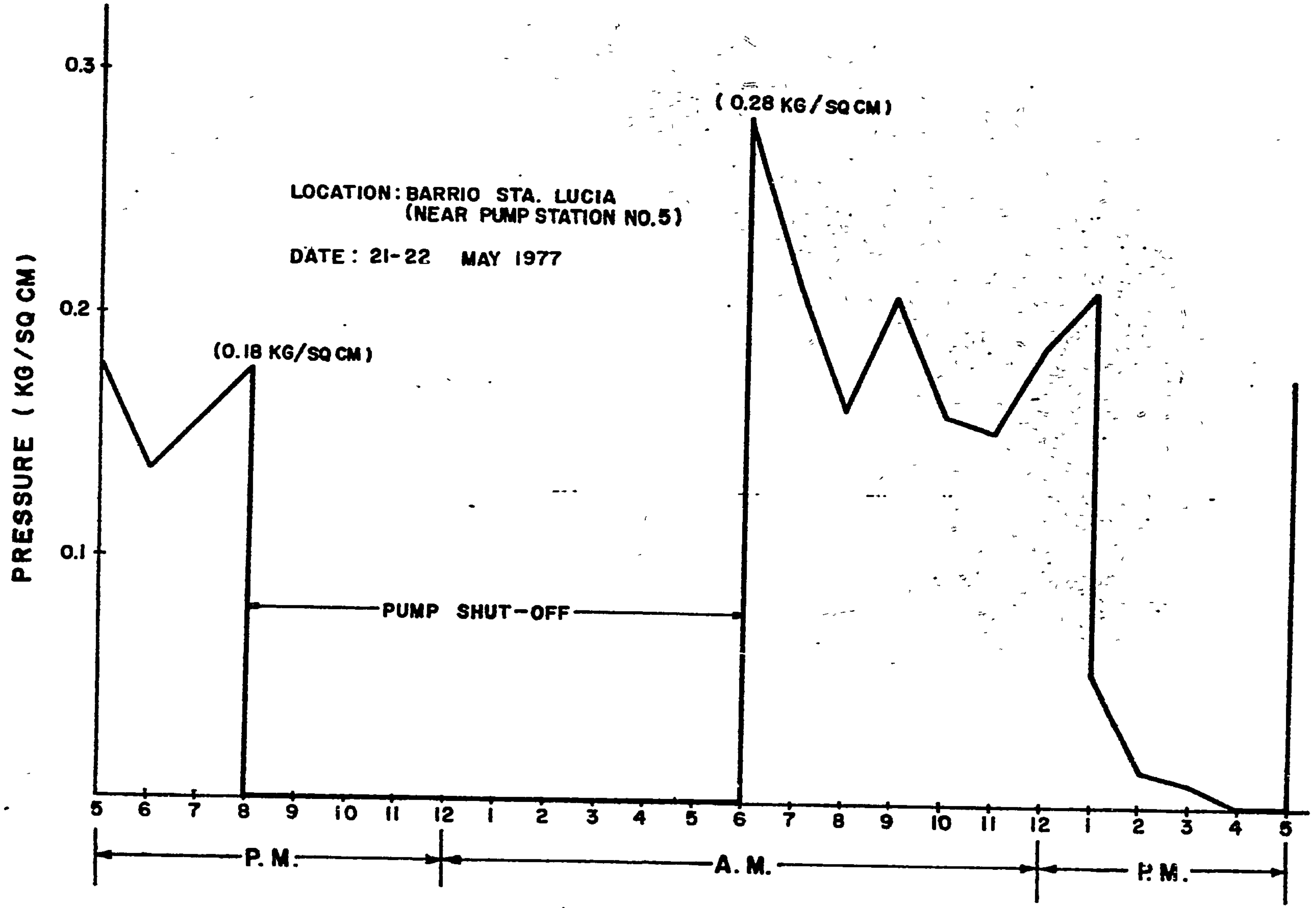
ANNEX FIGURE IV-E-14
24 HOUR SYSTEM PRESSURE
AT FIRE HYDRANT NO. 13
SAN FERNANDO WATER DISTRICT

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

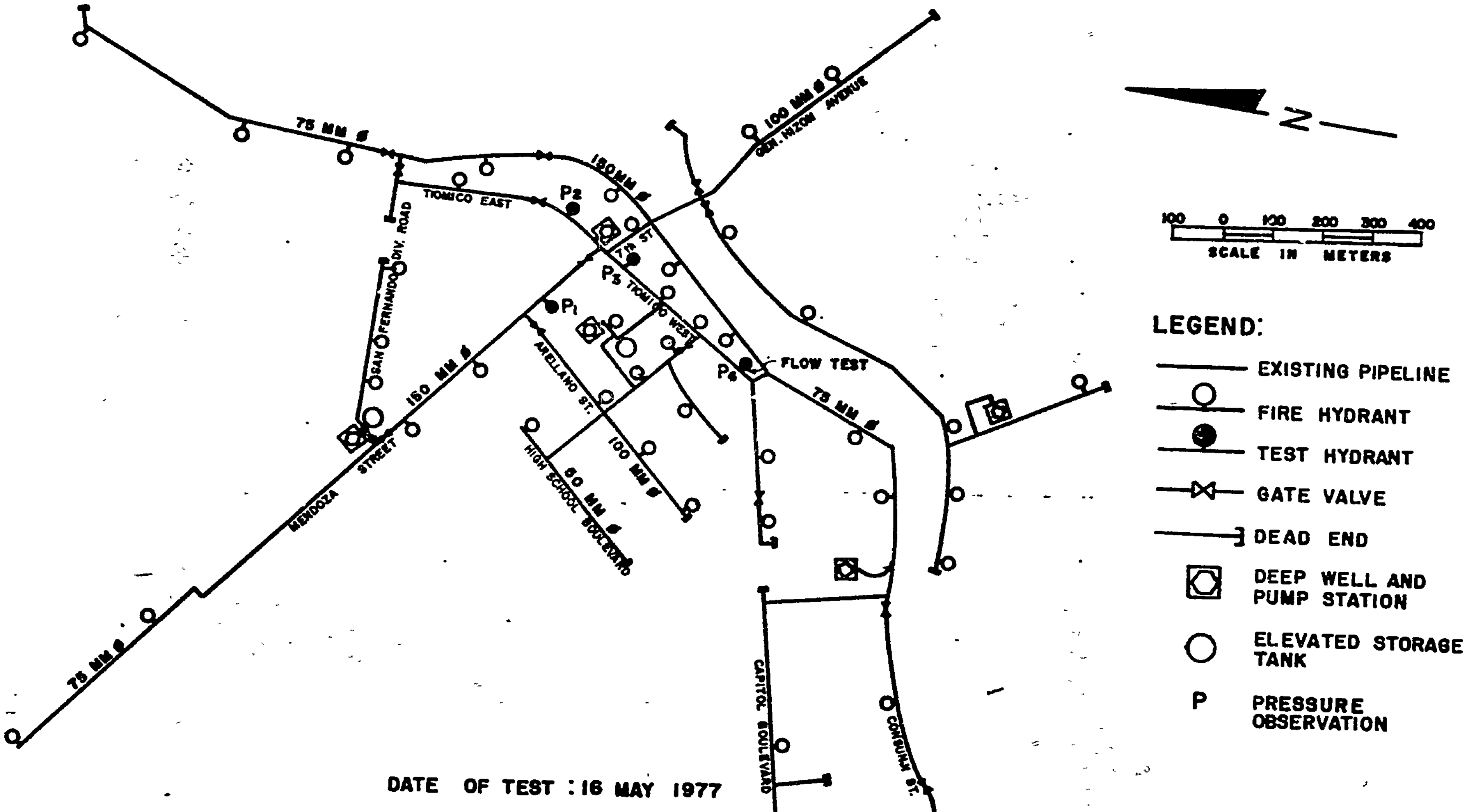


ANNEX FIGURE IV-E-15
24 HOUR SYSTEM PRESSURE
AT FIRE HYDRANT NO. 14
SAN FERNANDO WATER DISTRICT

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

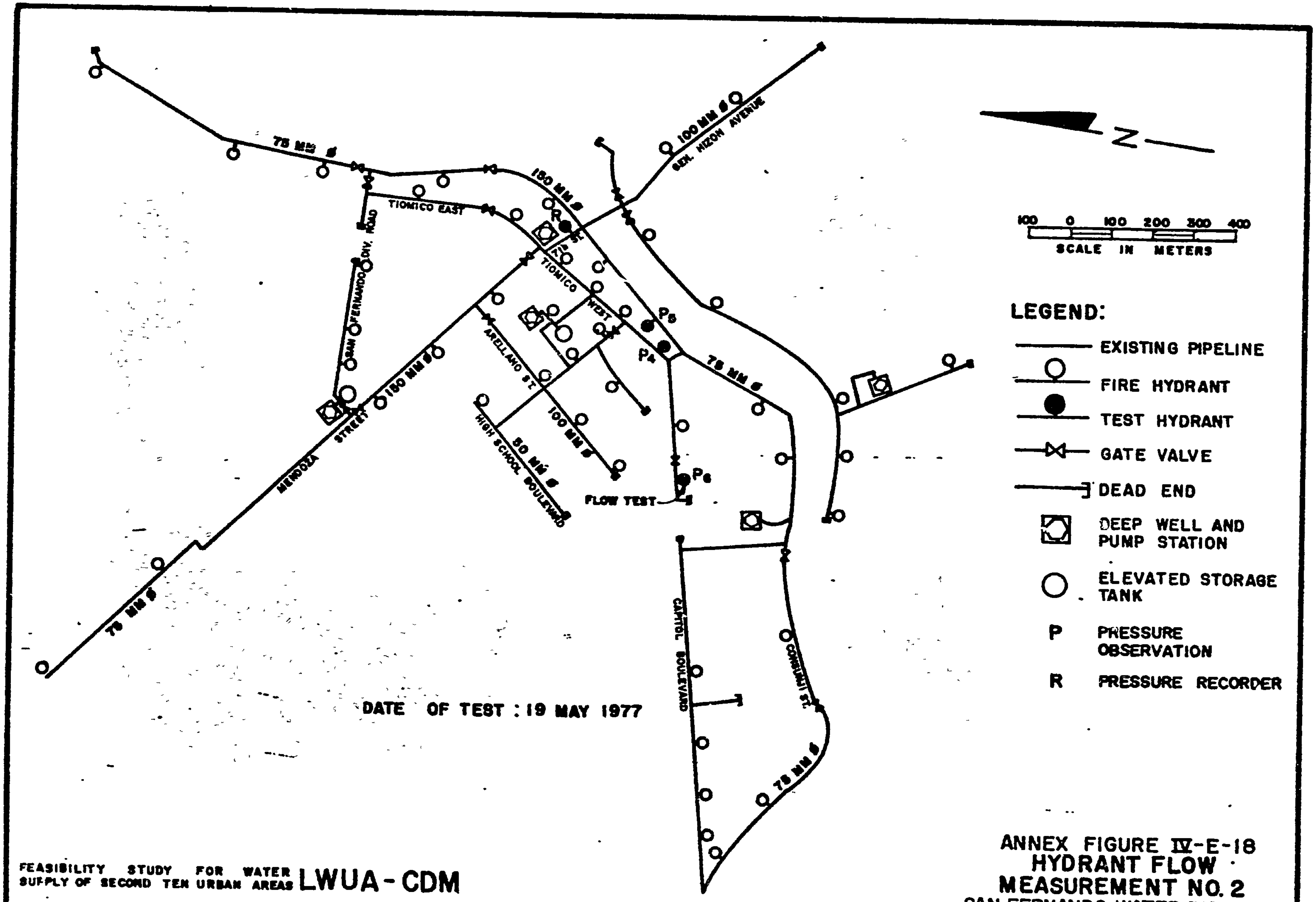


ANNEX FIGURE IV-E-16
24 HOUR SYSTEM PRESSURE
AT FIRE HYDRANT NO.15
SAN FERNANDO WATER DISTRICT



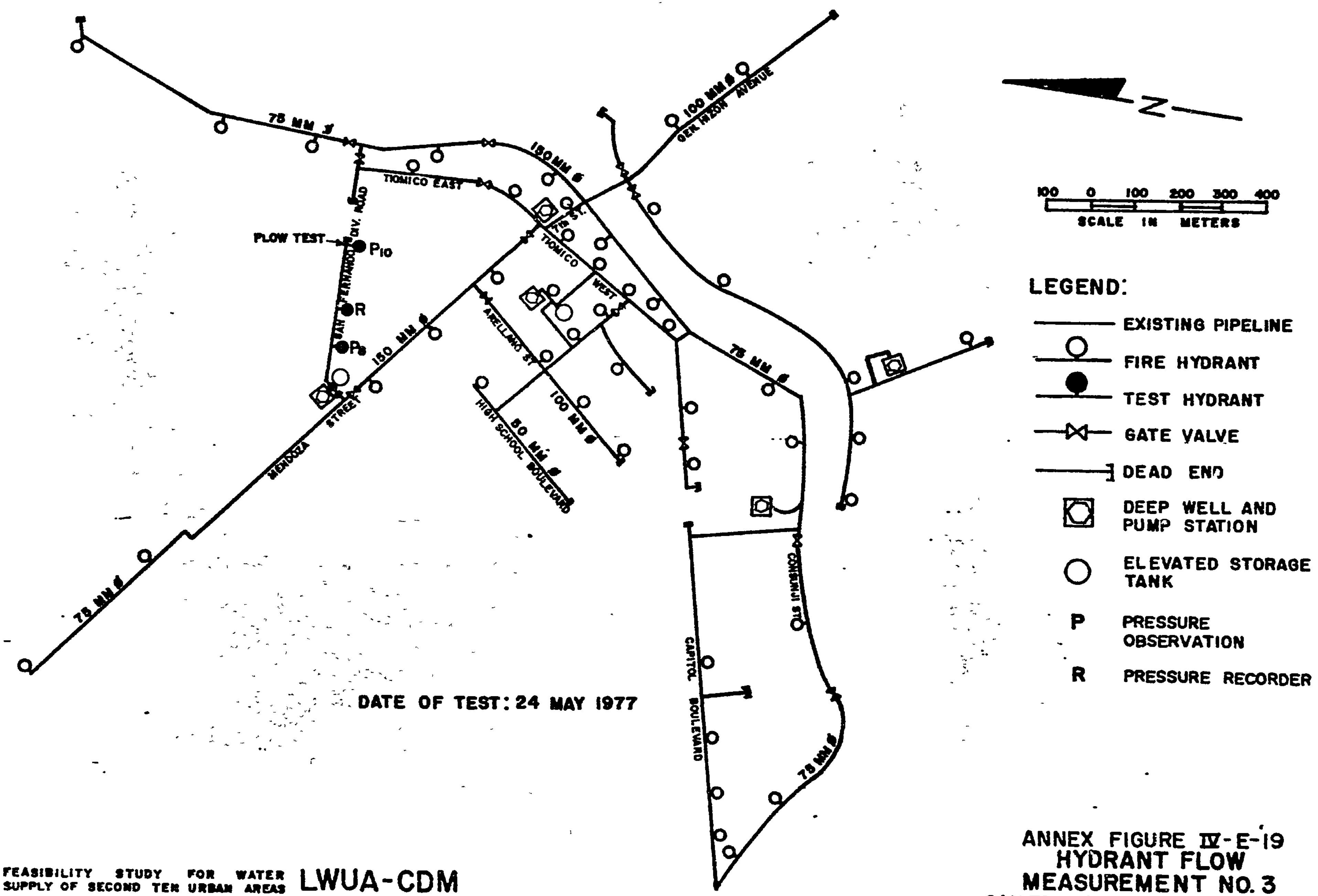
FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

ANNEX FIGURE IV-E-17
HYDRANT FLOW MEASUREMENT NO. 1
SAN FERNANDO WATER DISTRICT



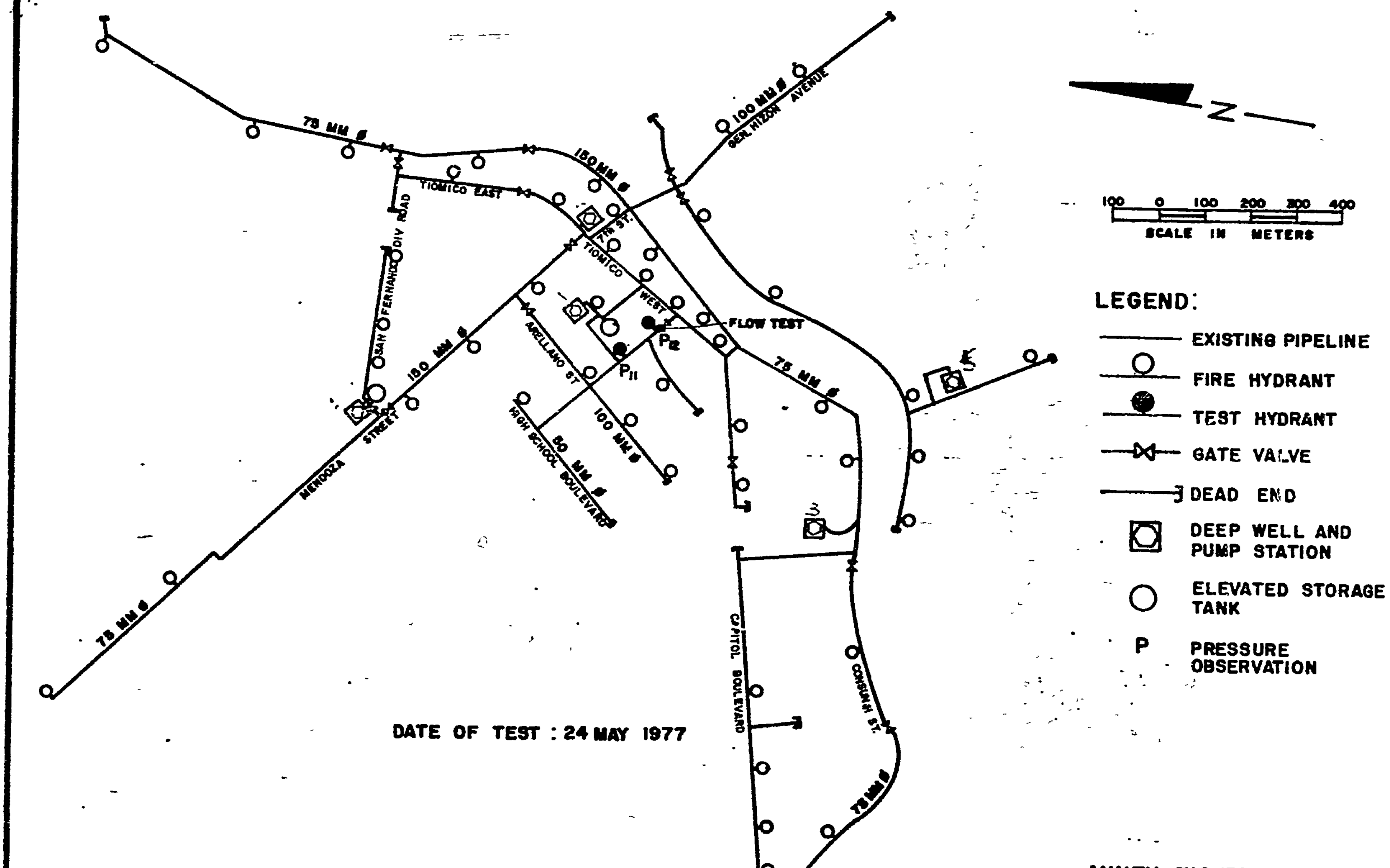
FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA - CDM

ANNEX FIGURE IV-E-18
HYDRANT FLOW MEASUREMENT NO. 2
SAN FERNANDO WATER DISTRICT



FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

ANNEX FIGURE IV-E-19
HYDRANT FLOW MEASUREMENT NO. 3
SAN FERNANDO WATER DISTRICT



FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS **LWUA-CDM**

ANNEX FIGURE IV-E-20
HYDRANT FLOW MEASUREMENT NO. 4
SAN FERNANDO WATER DISTRICT

CHAPTER V FEASIBILITY STUDY CRITERIA

A. GENERAL

The planning, design, economic, and financial criteria used in the water supply feasibility studies have been derived from studies of local conditions, accepted practices, standards and methods developed in the First Ten Provincial Urban Areas Feasibility studies. These criteria, together with the developed basis of cost estimates have been utilized to evaluate and compare the various alternatives identified in the course of the study.

In the analysis and evaluation of alternatives, feasibility study criteria need not be as refined as those used in the detailed development of the recommended scheme. Consistency is, however, essential. As long as each alternative to be analyzed is judged by similar criteria (or rules), the choice of alternatives will be accomplished in a fair and consistent manner.

B. PLANNING CRITERIA

This water supply feasibility study has been guided by the following planning criteria (not listed in order of importance):

1. <u>Areawide Approach:</u> Planning of facilities has been done on a regional or areawide basis taking into account the present district service boundaries and the logical long-term service areas beyond present district or political boundaries.

2. <u>Source of Water:</u> Groundwater and surface water have been given equal consideration as potential sources of water. However, based on the first 10 feasibility studies, disinfected groundwater derived from deep wells, when available, is expected generally to be more economical than conventionally treated surface water.

2. <u>Self-Sufficiency:</u> The recommended plan has been developed to provide the highest quality of water service within the "ability-to-pay" of the consumers.

4. <u>Conservation:</u> In the selection among alternative plans, water, power, chemicals and foreign exchange are considered valuable resources which must be conserved to the greatest extent possible.

5. <u>Stage Development:</u> The recommended long-range construction program has been divided into several stages, each of which satisfies the projected requirements for a specific design year.

Stage	Start Construction by Calendar Year	Target Design Year
Immediate Improvement	1978	1980
Phase I-A	1980	1985
Phase I-B	1986	1990
Phase II-A	1991	1995
Phase II-B	1996	2000

6. Alternative Plan Screening and Selection: From an array of identified plan alternatives, the recommended plan has been selected on the basis of least (present worth) cost and other non-economic parameters. The selected plan has been tested for economic/financial feasibility.

7. Skilled Manpower Shortage: The recommended plan has recognized, in the short term, the apparent shortage in skilled, technical and managerial expertise. Emphasis has been given on the need for district personnel training and certification.

8. Water Quality: The feasibility study has identified present and future water quality problems and includes recommendations for providing a water supply that is safe, healthful and wholesome.

9. Social Soundness: The successful completion of any project must take into account the social acceptability of its recommended programs (Appendix S, Volume II).

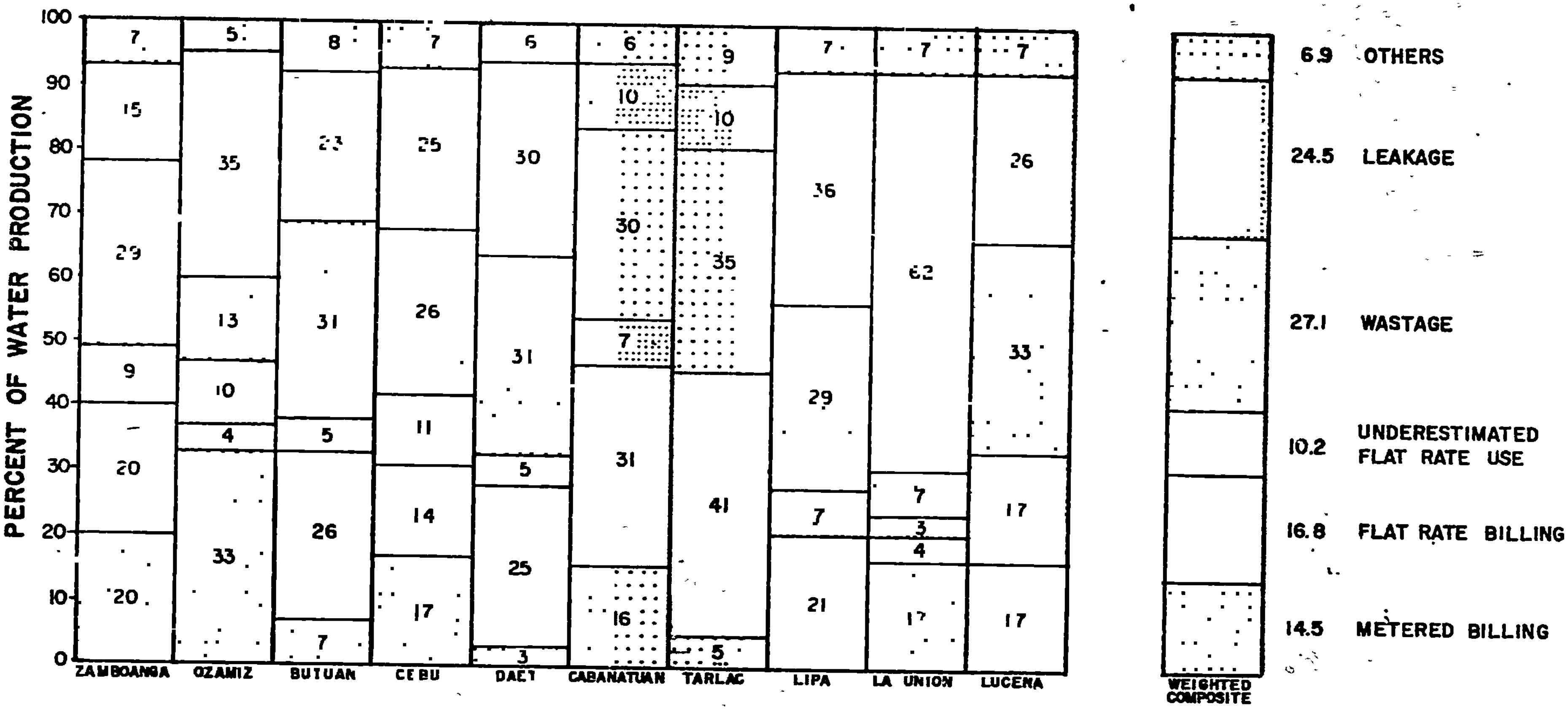
C. DESIGN CRITERIA

The basis of design for these feasibility studies is presented in detail in Appendix F, Volume II of this Report. The design criteria are basically similar to those utilized in the First Ten Provincial Urban Areas feasibility studies. Minor improvements/modifications have been made as indicated in the Methodology Memoranda attached herein in Volume I.

Water Accountability

As much as possible, water accountability has been determined through field testing and measurement procedures, augmented by data gathered in the pilot area study surveys (see Methodology Memoranda No. 1 and 2). Where field data were not available and the pilot area study survey results were not conclusive, the weighted average of the water accountability results in the First Ten Provincial Areas was used (see Figure V-1).

WATER ACCOUNTABILITY FOR FIRST TEN CITIES



FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS **LWUA-CDM**

FIGURE V-1
WATER ACCOUNTABILITY
FIRST 10 CITIES

The breakdown of the water accountability is as follows:

	Percent of Water Production
Metered Billing	14.5
Flat-Rate Billing	16.8
Underestimated Flat-Rate Use	10.2
Wastage	27.1
Leakage	24.5
Others	6.9
	100.0

Water Demand Grouping

A procedure has been developed to classify communities in the Philippines into one of 5 groups for purposes of water demand projections. Available data on population, population growth, housing, income and other economic and technical parameters are used in the classification, with a system of weighting (see Methodology Memorandum No. 3). In general, the water demand requirements per capita through the period 1980-2000 are as follows:

Group 1	261 - 273 lpcd
Group 2	220 - 230 lpcd
Group 3	193 - 199 lpcd
Group 4	174 - 181 lpcd
Group 5	157 - 165 lpcd

The above values include domestic water needs; allowances for nominal commercial, industrial and institutional use; and a decreasing percentage of unaccounted-for-water in time.

For the analysis of existing conditions, actual metered (or connected) customers and "borrowers" are considered separately (see Methodology Memorandum No. 2). However, for short- and long-range planning, it has been assumed that "borrowers" would eventually become metered consumers. Per capita domestic use has been increased each year to account for economic growth within the community. Institutional and commercial water demands have been estimated as a percentage of domestic demand (see Methodology Memorandum No. 3).

Demand Variation

Maximum daily and peak hourly demands have been estimated from field data and available records. For the basic analysis of the water supply facilities, the following ratios have been used:

maximum-day to average-day ratio = 1.2:1
peak-hour to average-day ratio = 1.5:1 - 1.75:1

D. ECONOMIC AND FINANCIAL CRITERIA

Discount Rate

The opportunity cost of capital or discount rate used in this feasibility study is 12 percent. The discount rate has been used for economic screening of the technically viable alternatives (see Chapter IX, Methodology Manual on Water Supply Feasibility Studies, Volume I).

Inflationary Trends

The national economy of the Philippines is discussed in Appendix E, Volume II.

Projections made in this feasibility study assume a general cost escalation rate of 10 percent for the period 1978 through 1980; 8 percent for the period 1981-1985; and 6 percent thereafter. The cost of maintenance and operation is assumed to escalate at 8 percent per annum.

Economic Justification

The economic feasibility of this water supply project is based on 2 parameters: benefit-cost ratio (B/C) and the internal economic rate of return (IERR). These parameters are discussed in Chapter XI.

Financial Criteria

The financial justification of this project is based on the district customers' ability-to-pay (see Chapters XX and XXI, Methodology Manual) and a suggested socialized pricing scheme, based on increasing unit cost of water with increasing consumption (see Chapter X).

E. BASIS OF COST ESTIMATES

Construction cost curves have been developed for inplace costs of pipelines, deep wells, water treatment plants, pump stations, and storage reservoirs. These cost curves have been used for estimating the relative cost magnitudes of alternative water supply plans. Escalation factors used in calculating the capital cost of recommended improvements in July 1978 prices, as well as the above unit costs, are presented in Appendix G, Volume II.

F. IMPLEMENTATION SCHEDULE

For purposes of feasibility study and economic/financial analyses, an implementation schedule has been assumed. Figure V-2 shows the probable time-table which covers the planning, design, and implementation of Phase I-A. It is assumed in these feasibility studies that the recommended Immediate Improvement Program (see Interim Report, February 1978) is to be fully implemented by the LWUA Interim Demonstration Program by 1980.

PHASE I-A PROJECT SCHEDULE

Final Report Submission	March	1978
Select Final Design Engineer	December	1978
Start Final Design	May	1979
Complete Final Design	December	1979
Start Construction	May	1980

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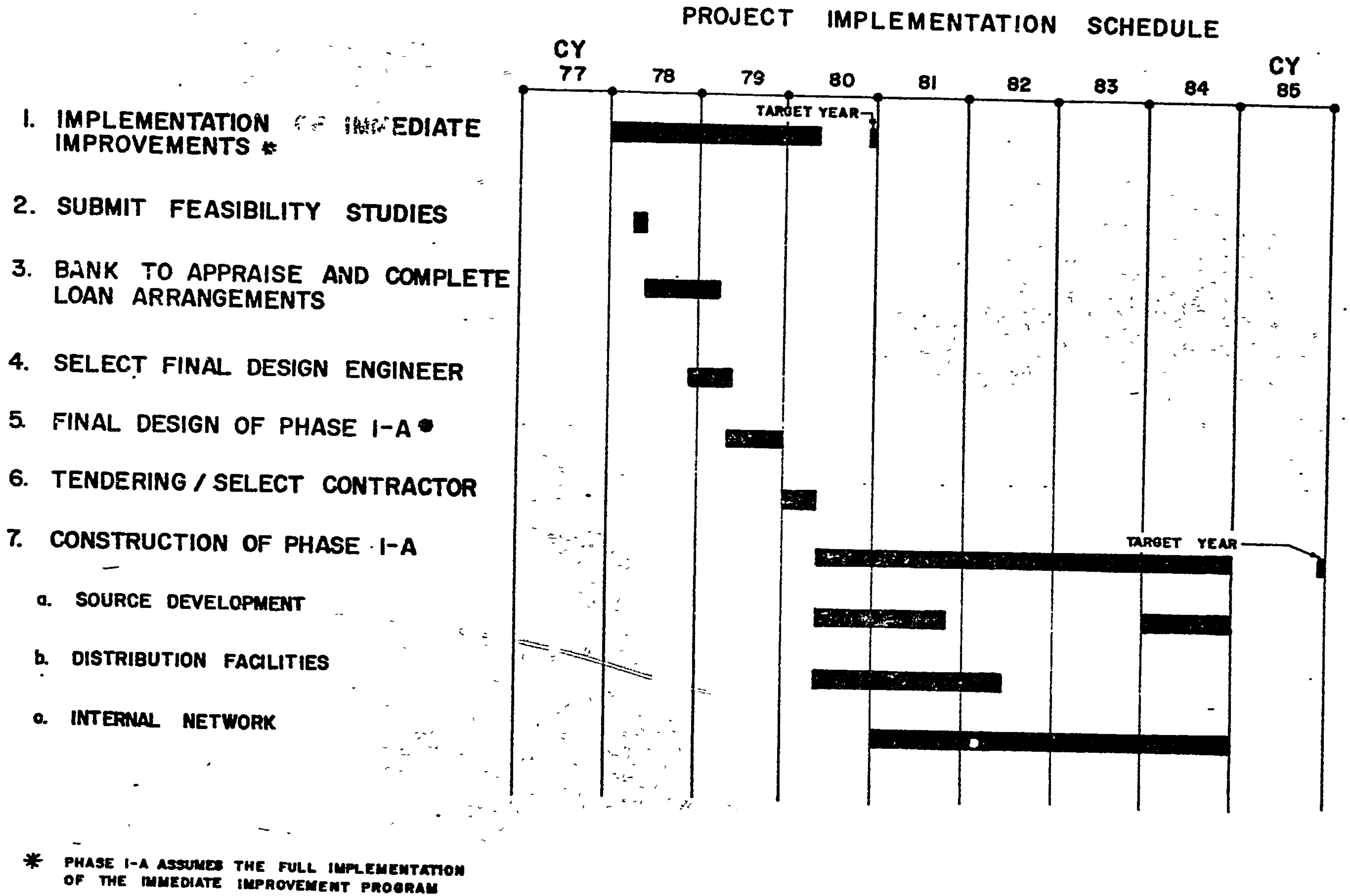


FIGURE V-2
PROJECT IMPLEMENTATION SCHEDULE
SAN FERNANDO WATER DISTRICT

CHAPTER VI POPULATION AND WATER DEMAND PROJECTIONS

A. GENERAL

A necessary step in developing the preliminary design of a water system is the projection of served population and water demand for the delineated service area. These projections significantly affect facility layouts and sizes, construction staging and cost of the project. The projections for the FER-WD are discussed in this chapter.

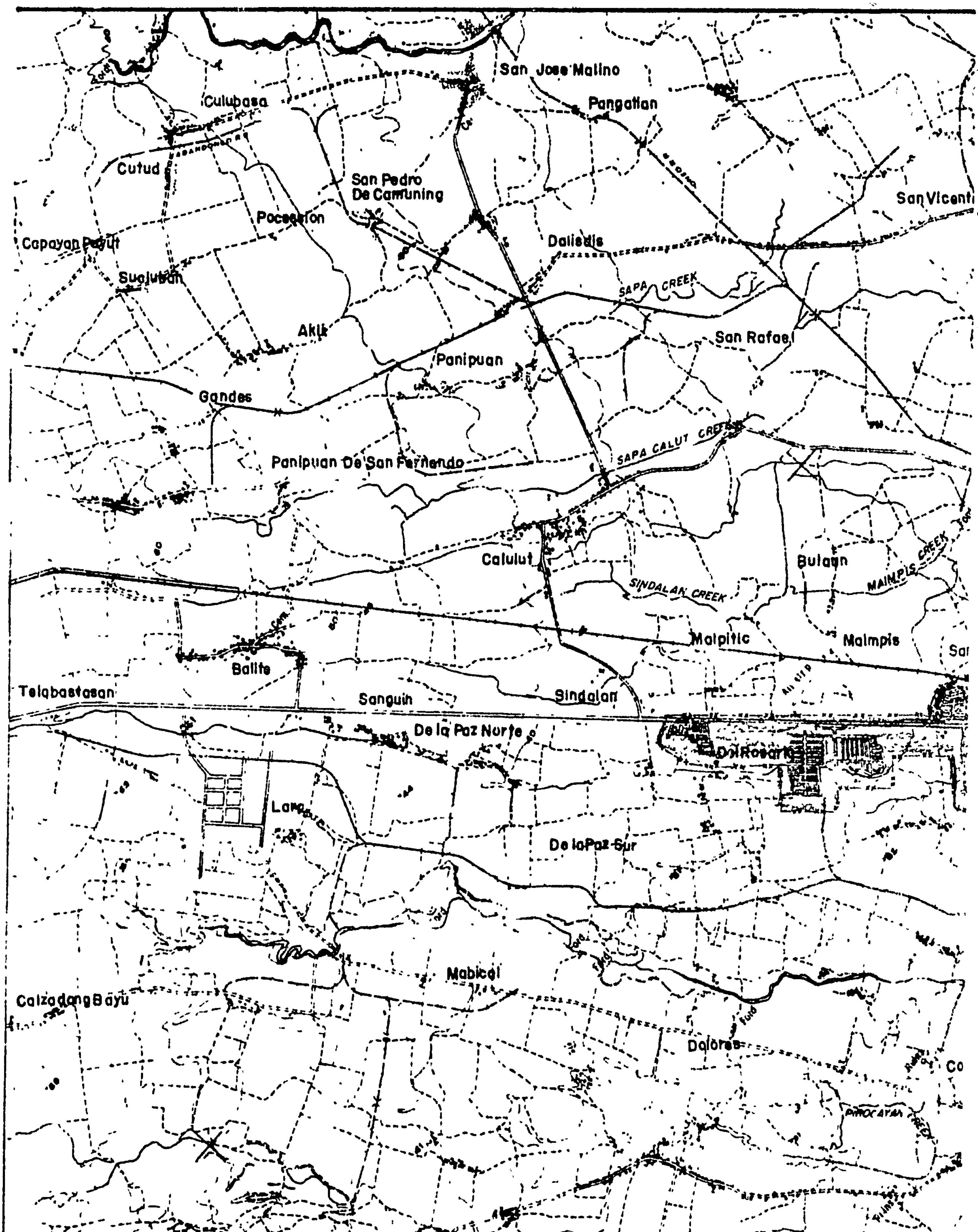
B. POPULATION PROJECTIONS

The population and corresponding growth rates of San Fernando from 1948 to 1975 as recorded by the NCSO are shown below and compared with the growth rates of Pampanga and the Philippines for the same period.

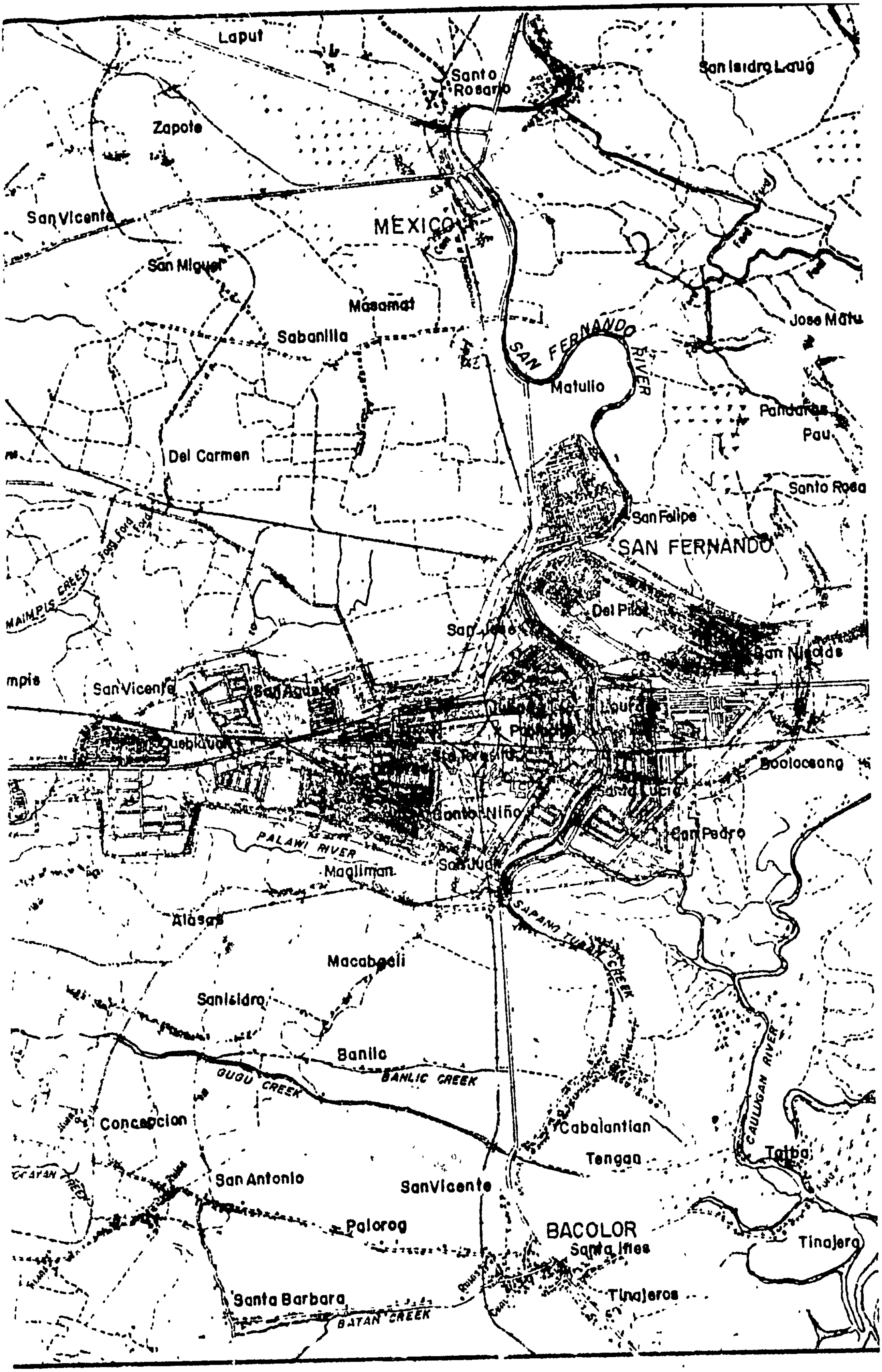
Year	Population	Annual Growth (%)	Provincial Growth (%)	National Growth (%)
1948	39,549			
1960	56,861	3.07 (1948-60)	3.33	3.10
1970	84,362	4.02 (1960-70)	3.93	3.00
1975	98,382	3.12 (1970-75)	2.81	2.66

Except for the period 1948-1960, the annual population growth rates for San Fernando were slightly higher than the provincial and national growth rates. The increase in population growth rate for 1960-1970 was caused primarily by the migration to San Fernando of the working populace attracted by the employment opportunities generated by emerging establishments like banks, hospitals, colleges, manufacturing and industrial firms (the Pampanga Sugar Development Company, the San Miguel Corporation and Pepsi-Cola Bottling Company are among the largest industrial firms). The economic growth and social progress were enhanced by the peace and order condition of the town, in contrast to the neighboring towns troubled by insurgent movement arising from agrarian problems. The decrease in growth rate for the period 1970-1975 for San Fernando can be correlated to the decrease in the provincial and national growth rates for the same period.

Population projections for the years 1970-2000 for San Fernando were also made by the National Economic and Development Authority (NEDA) and the Commission on Population (POPCOM) and discussed in Appendix H, Volume II. These projections are as follows:



FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM



Laput
Santo Rosario
San Isidro Laug
Zapote
San Vicente
MEXICO
San Miguel
Masamat
Sabanilla
SAN FERNANDO RIVER
Matulio
Jose Matu
Pandaras
Pau
Del Carmen
Santo Rosa
San Felipe
SAN FERNANDO
MAIMPIS CREEK
Del Pilar
San Nicolas
San Vicente
Boolocsang
Santo Niño
San Pedro
PALAWI RIVER
Magliman
San Juan
Alasas
SAPANG TUBAN CREEK
Macabacli
San Isidro
Banlic
GUGU CREEK
BANLIC CREEK
CAULUGAN RIVER
Concepcion
Cabalantian
Tengaa
Talba
San Antonio
SanVicente
Palorog
BACOLOR
Tinajero
Santa Ines
Santa Barbara
Tinajeros
BATAN CREEK

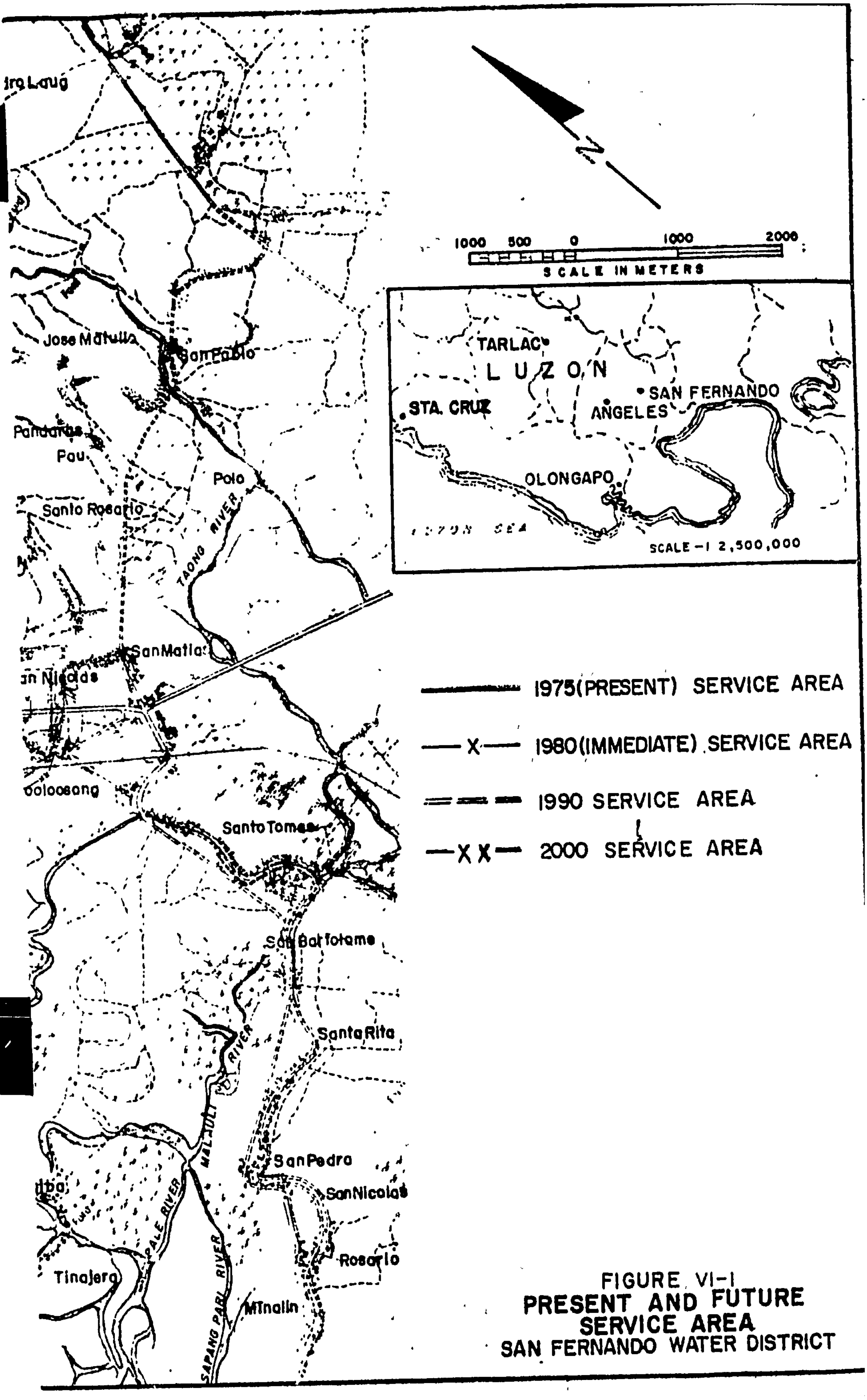


FIGURE VI-1
PRESENT AND FUTURE SERVICE AREA
SAN FERNANDO WATER DISTRICT

tion from rural to urban areas. However, the growth rates for the service area have been projected to decrease gradually from 1980 to the year 2000. This decrease will be a result of the wider acceptance of family planning in San Fernando and the saturation of the service area.

Projected service area populations are shown in Table VI-1 and Figure VI-2 and are summarized as follows:

Year	Total Population	Overall Annual Growth Rate(%)	Population in Service Area	Service Area (ha)	Average Density in Service Area (persons/ha)
1975(present)	76,549		26,498	206	129
1980(immediate)	93,190	4.01 (1975-1980)	44,620	351	127
1990	125,260	3.00 (1980-1990)	86,510	821	105
2000	165,210	2.80 (1990-2000)	148,090	1,387	107

The analysis shows that the population in the service area will increase from 26,498 in 1975 to 148,090 in the year 2000. The total population of the poblacion and other barrios included in the projected service area will increase from 76,549 in 1975 to 165,210 in the year 2000 or more than twice the 1975 population within a span of 25 years. Densities in the service area will average between 105-129 persons per hectare. Overall annual growth rates in this area will decline from 4.01 in 1980 to 2.80 percent in 2000.

C. PROJECTIONS FOR SERVED POPULATION

The served population in the FER-WD is projected to increase significantly in the next two decades. The increase will be a result of: (1) the intense campaign of the FER-WD to connect and reconnect as many customers as possible; (2) the desire of the residents in the FER-WD to partake of the benefits of modern piped system; and (3) the increase in population and in the geographical coverage of the FER-WD.

Table VI-2 shows the breakdown of the served population projections for the poblacion of San Fernando and the barrios within the service area. Figure VI-2 shows that the served population in the year 2000 will increase more than six times the 1980 served population. The served population in the present service area will grow faster than that in the future service area extensions. During the period 1975-2000, the increase in population would be highest in the decade 1990-2000. The served population projections are summarized as follows:

TABLE VI-1

SERVICE AREA POPULATION PROJECTIONS
SAN FERNANDO WATER DISTRICT

	Population 1975	Present Service Area: Population in Service Area	Service Area(ha)	Density Persons/Ha	Immediate Service Area: Population in Service Area	Service Area(ha)	Density Persons/Ha	1990 Service Area: Population in Service Area	Service Area(ha)	Density Persons/Ha	2000 Service Area: Population in Service Area	Service Area(ha)	Density Persons/Ha
Poblacion*	9,077	7,262	48	151	9,030	56	161	11,430	64	179	15,030	73	205
Sta. Lucia	7,904	4,742	37	128	7,640	55	139	10,950	72	152	13,090	78	168
San Pedro	3,569	1,428	11	130	2,250	16	141	3,800	25	152	6,940	52	134
Dolores	8,563	860	6	143	2,170	13	167	9,250	142	65	17,070	154	111
Juliana	2,805	1,964	8	246	2,240	10	224	3,870	15	258	4,620	15	308
Del Pilar	8,200	1,230	9	137	4,890	44	111	13,280	98	136	17,680	102	173
San Jose	7,668	1,534	8	192	3,660	15	244	4,970	26	191	13,350	108	124
San Juan	2,712	814	21	39	1,280	42	30	2,180	103	21	4,090	194	21
Santo Niño	9,520	6,664	58	115	9,630	82	117	12,940	94	138	21,320	108	197
San Nicolas	7,199	-	-	-	1,830	18	102	7,810	44	178	17,850	78	229
San Agustin	4,366	-	-	-	-	-	-	4,790	63	76	8,740	122	72
San Felipe	1,119	-	-	-	-	-	-	1,240	78	16	2,070	88	23
Quebiawan	1,047	-	-	-	-	-	-	-	-	-	1,760	70	25
San Isidro	1,925	-	-	-	-	-	-	-	-	-	3,400	107	32
Del Rosario	875	-	-	-	-	-	-	-	-	-	1,080	38	29
TOTAL	76,549	26,498	206	129	44,620	351	127	86,510	824	105	148,090	1,387	107

*Includes barrios Sta. Teresita and Lourdes

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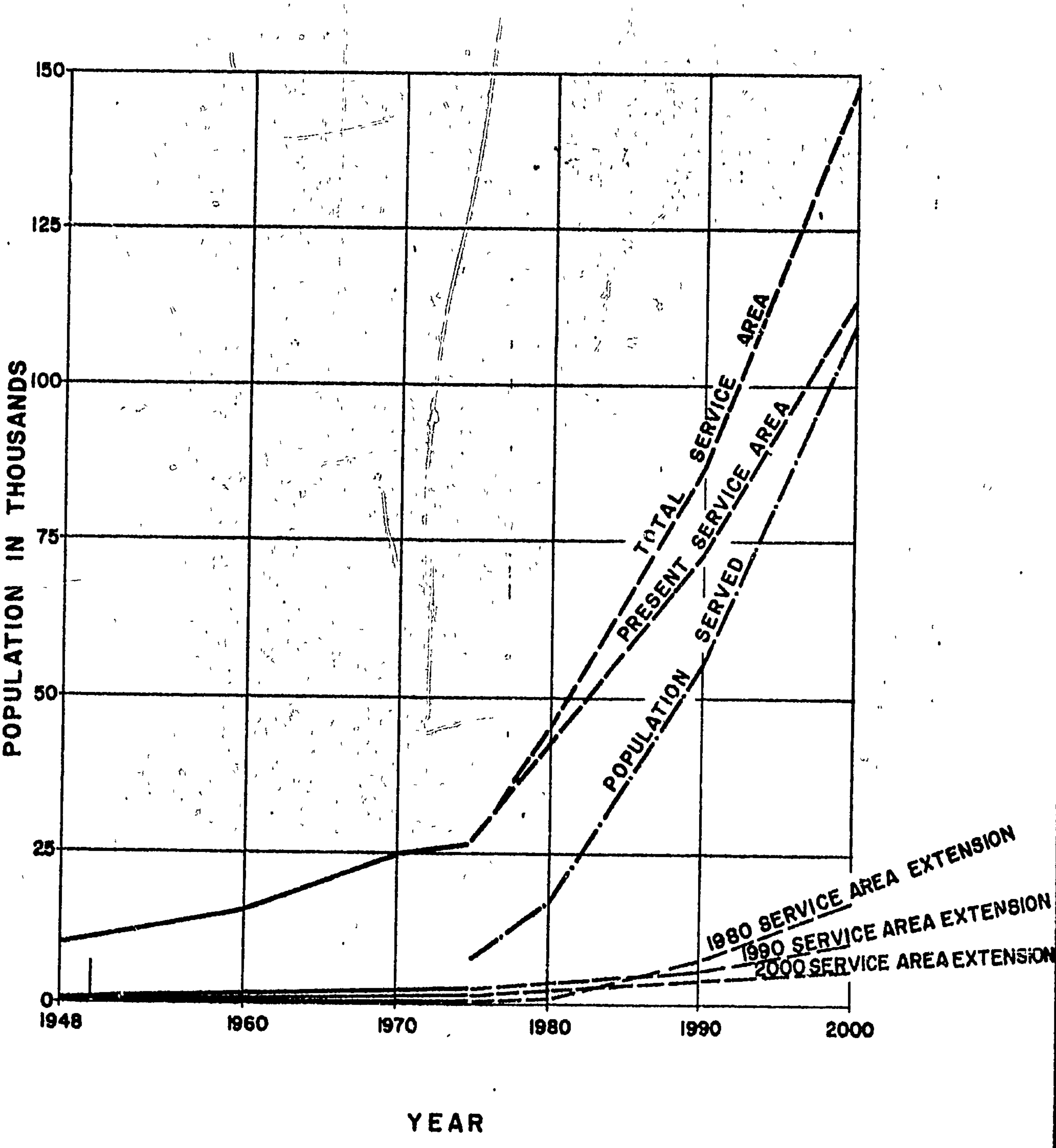

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS

LWUA-CDM

FIGURE VI—2
POPULATION PROJECTION
SAN FERNANDO WATER DISTRICT

TABLE VI-2

SERVED POPULATION PROJECTIONS
SAN FERNANDO WATER DISTRICT

	Present Service Area	1980 Immediate Service Area	1990 Service Area	2000 Service Area
I. POBLACION*				
A. Population in Service Area	7,262	9,030	11,430	15,030
B. Number of Service Connections	516	730	1,770	2,570
C. Connected Population	3,612	4,970	10,630	14,130
D. % Connected	50%	55%	93%	94%
II. STA. LUCIA				
A. Population in Service Area	4,742	7,640	10,950	13,090
B. Number of Service Connections	118	210	550	1,140
C. Connected Population	826	1,440	3,290	6,280
D. % Connected	17%	19%	30%	48%
III. SAN PEDRO				
A. Population in Service Area	1,428	2,250	3,800	6,940
B. Number of Service Connections	79	200	560	1,140
C. Connected Population	553	1,360	3,340	6,250
D. % Connected	39%	60%	88%	90%
IV. DOLORES				
A. Population in Service Area	860	2,170	9,250	17,070
B. Number of Service Connections	57	210	1,390	2,790
C. Connected Population	400	1,440	8,330	15,360
D. % Connected	47%	66%	90%	90%

*Includes Sta. Teresita and Lourdes

TABLE VI-2 (Continued)

	Present Service Area	1980 Immediate Service Area	1990 Service Area	2000 Service Area
V. JULIANA				
A. Population in Service Area	1,964	2,240	3,870	4,620
B. Number of Service Connections	132	210	560	730
C. Connected Population	924	1,440	3,330	4,020
D. % Connected	50%	64%	86%	87%
VI. DEL PILAR				
A. Population in Service Area	1,230	4,890	13,280	17,680
B. Number of Service Connections	25	130	890	2,060
C. Connected Population	175	880	5,310	11,310
D. % Connected	14%	18%	40%	64%
VII. SAN JOSE				
A. Population in Service Area	1,534	3,660	4,970	13,350
B. Number of Service Connections	130	300	700	2,090
C. Connected Population	910	2,020	4,220	11,480
D. % Connected	59%	55%	85%	86%
VIII. SAN JUAN				
A. Population in Service Area	814	1,280	2,180	4,090
B. Number of Service Connections	25	120	320	660
C. Connected Population	175	800	1,920	3,640
D. % Connected	21%	63%	88%	89%
IX. STO. NIÑO				
A. Population in Service Area	6,664	9,630	12,940	21,320
B. Number of Service Connections	163	340	1,340	2,790
C. Connected Population	1,140	2,310	8,020	15,350
D. % Connected	17%	24%	62%	72%

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TABLE VI-2 (Continued)

	Present Service Area	1980 Immediate Service Area	1990 Service Area	2000 Service Area
X. SAN NICOLAS				
A. Population in Service Area		1,830	7,810	17,850
B. Number of Service Connections		45	560	2,210
C. Connected Population		320	3,360	12,140
D. % Connected		17%	43%	68%
XI. SAN AGUSTIN				
A. Population in Service Area			4,790	8,740
B. Number of Service Connections			400	1,050
C. Connected Population			2,390	5,770
D. % Connected			50%	66%
XII. SAN FELIPE				
A. Population in Service Area			1,240	2,070
B. Number of Service Connections			90	230
C. Connected Population			510	1,240
D. % Connected			41%	60%
XIII. QUEBIAUAN				
A. Population in Service Area				1,760
B. Number of Service Connections				130
C. Connected Population				40%
XIV. SAN ISIDRO				
A. Population in Service Area				3,400
B. Number of Service Connection				280
C. Connected Population				1,530
D. % Connected				45%

TABLE VI-2 (Continued)

	Present Service Area	1980 Immediate Service Area	1990 Service Area	2000 Service Area
XV. DEL ROSARIO				
A. Population in Service Area				1,080
B. Number of Service Connections				70
C. Connected Population				380
D. % Connected				35%
Total Number of Connections	1,245	2,495	9,130	19,940
Total Population	26,498	44,620	86,510	148,090
Total Connected Population	8,715	16,980	54,650	109,580
% Served Population	33%	38%	63%	74%

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Year	Projected Served Population	Population in the Service Area	Percent Served
1975 (present)	8,715	26,498	33
1980 (immediate)	16,980	44,620	38
1990	54,650	86,510	63
2000	109,580	148,090	74

Table VI-3 shows the year-by-year projections of the served population.

D. WATER DEMAND PROJECTIONS

The water demand of the FER-WD has been projected to increase significantly as a result of continuous growth in served population. Per capita domestic water use, commercial/industrial/institutional use, as well as unaccounted-for-water (expressed as percent of production) have been estimated for the years 1980, 1990, and 2000 for the service area. Based on analyses (see Methodology Memorandum No. 3), FER-WD has been classified under Group II, which has the following water use parameters:

	1980	1990	2000
Domestic use, lpcd	120	135	150
Commercial/industrial/institutional, lpcd	18	23	30
Accounted-for-water, lpcd	138	158	180
% Unaccounted-for-water	40	28	20
Total Water Demand, lpcd	230	220	225

Using the above water demand parameters and the projected served populations, the water demands for the design years 1980, 1990 and 2000 are as follows (see Table VI-3 and Figure VI-3):

	1980	1990	2000
Water demand (lpcd)	230	220	225
Served population	16,980	54,650	109,580
Average daily water demand (cumd)	3,910	12,020	24,660
Maximum-day water demand[1] (cumd)	4,690	14,420	29,590
Peak-hour water demand[2] (cumd)	6,840	21,040	43,150

The unaccounted-for-water is estimated to diminish from 40 percent in 1980 to 20 percent of total water demand by the year 2000. This decrease in unaccounted-for-water will be a result of the water district's efforts to minimize water losses through an extensive leakage and wastage survey and repair program, total metering of all connections, and sound management and operation practices.

1/ Based on 1.2 times average daily water demand.
2/ Based on 1.75 times average daily water demand.

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TABLE VI-3

YEAR-BY-YEAR PROJECTIONS OF SERVED POPULATION
AND WATER DEMAND
SAN FERNANDO WATER DISTRICT

Year	Served Population	Average-Day Demand (cumd)	Maximum-Day Demand (cumd)	Peak-Hour Demand (cumd)
1978	10,600	2,400	2,880	4,200
1979	13,420	3,050	3,660	5,340
1980	16,980	3,910	4,690	6,840
1981	19,080	4,370	5,240	7,650
1982	21,450	4,890	5,870	8,560
1983	24,110	5,470	6,560	9,570
1984	27,100	6,120	7,340	10,710
1985	30,460	6,850	8,220	11,990
1986	34,240	7,670	9,200	13,420
1987	38,480	8,580	10,300	15,020
1988	43,260	9,600	11,520	16,800
1989	48,620	10,740	12,890	18,800
1990	54,650	12,020	14,420	21,040
1991	58,590	12,920	15,500	22,610
1992	62,810	13,880	16,660	24,290
1993	67,330	14,910	17,900	26,100
1994	72,180	16,020	19,220	28,040
1995	77,390	17,220	20,660	30,130
1996	82,960	18,500	22,200	32,380
1997	88,940	19,880	23,850	34,790
1998	95,350	21,360	25,630	37,380
1999	102,220	22,950	27,540	40,160
2000	109,580	24,660	29,590	43,150

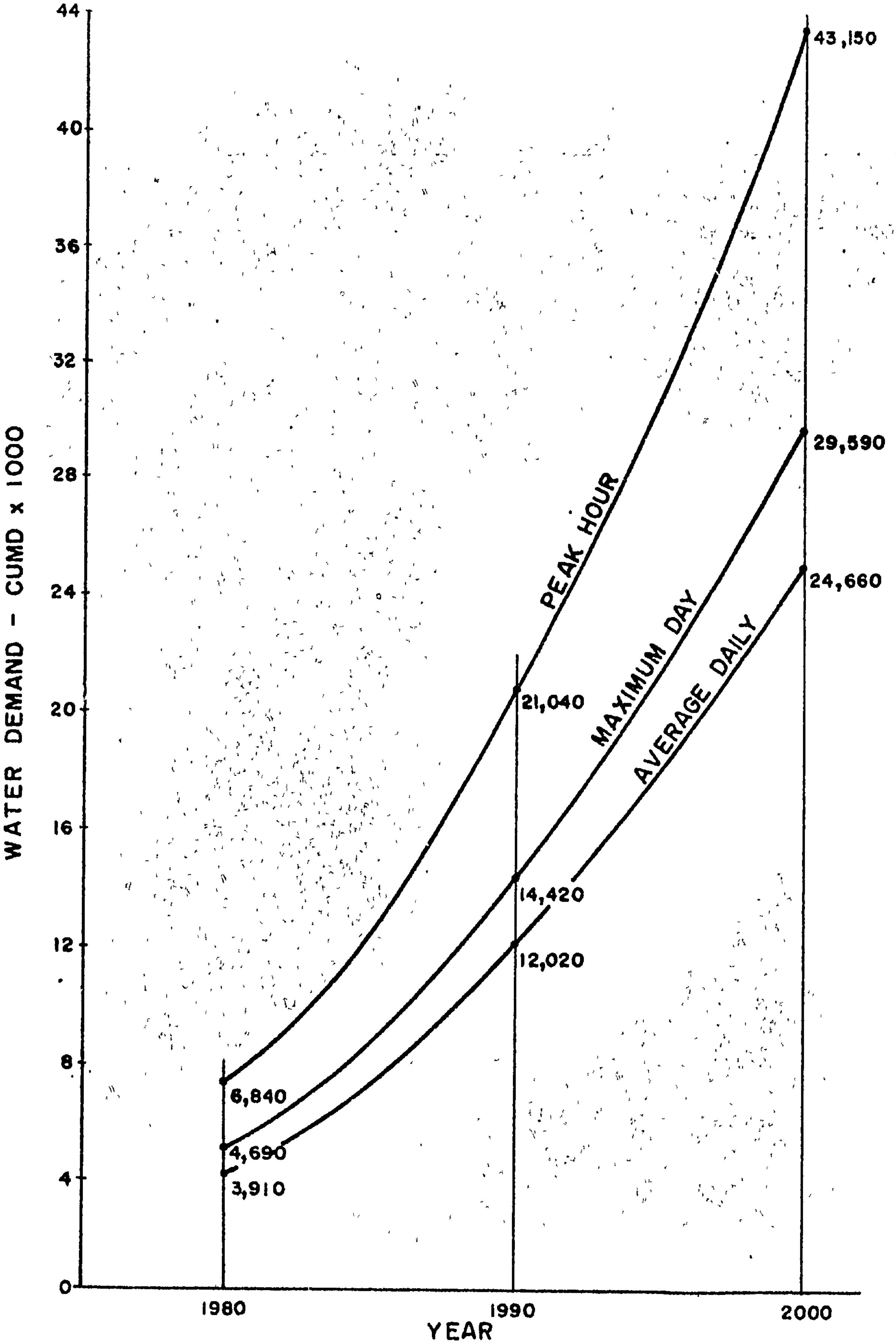


FIGURE VI-3
PROJECTED WATER DEMAND
SAN FERNANDO WATER DISTRICT

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

CHAPTER VII WATER RESOURCES

A. GENERAL

The FER-WD currently obtains all of its water supply from old wells of moderate capacity. The possible sources of additional supply for San Fernando are groundwater and surface water from the Pampanga River and smaller nearby rivers. Water rights to the chosen source must be obtained from the National Water Resources Council by FER-WD as expediently as possible.

B. GROUNDWATER RESOURCES

The FER-WD is located in the southern part of the Central Plain of Luzon and the entire present and projected service area lies within the Central Plain, a very productive groundwater region. Wells are in almost all cases used for city, private and industrial water supply but are not currently in use for large-scale irrigation near San Fernando. Most of the wells in the immediate vicinity of the FER-WD considered for this study are shown in Figure VII-1. Numerous additional distant wells were studied for regional analysis. Relevant information on wells is shown in Annex Table VII-B-1. The critical factor in groundwater exploitation is control to avoid overproduction, rather than the immediate technical problems of production. Even at present production rates, groundwater levels are declining, thereby increasing pumping costs and threatening to cause sea water intrusion.

Geology and Topography

The Central Plain of Luzon is the physiographic expression of a large structural trough separating the Zambales Mountains to the west from the Sierra Madre Mountains to the east and the Caraballo Mountains to the north. This trough was depressed below sea level repeatedly during Tertiary and Early Quaternary times. The trough was last filled to its present extent with material washed down from the mountain slopes and deposited in the form of fan and deltaic deposits and, later, flood plain deposits. The deepest well in the Pampanga area is over 280 meters deep (at Lubao) and penetrates only part of the Quaternary alluvium, but the underlying rocks can be inferred from exposures of older rocks in the hills and mountains that lie to the north, east and west.

The basement complex exposed in the Sierra Madre and Zambales Mountains consists of basic igneous and metamorphic rocks probably of Cretaceous to Early Tertiary Age. Overlying the basement are tuffaceous clastic sedimentary rocks (shales, siltstones, sandstones, conglomerates) of Middle to Late Tertiary Age. Limestones are observed locally. The Tertiary sediments in part are overlain by the Quaternary Guadalupe tuff (or other tuffaceous beds of similar age) composed of waterlain, angular volcanic debris. These sediments, in turn, are overlain by the alluvium that fills the depressed plain.

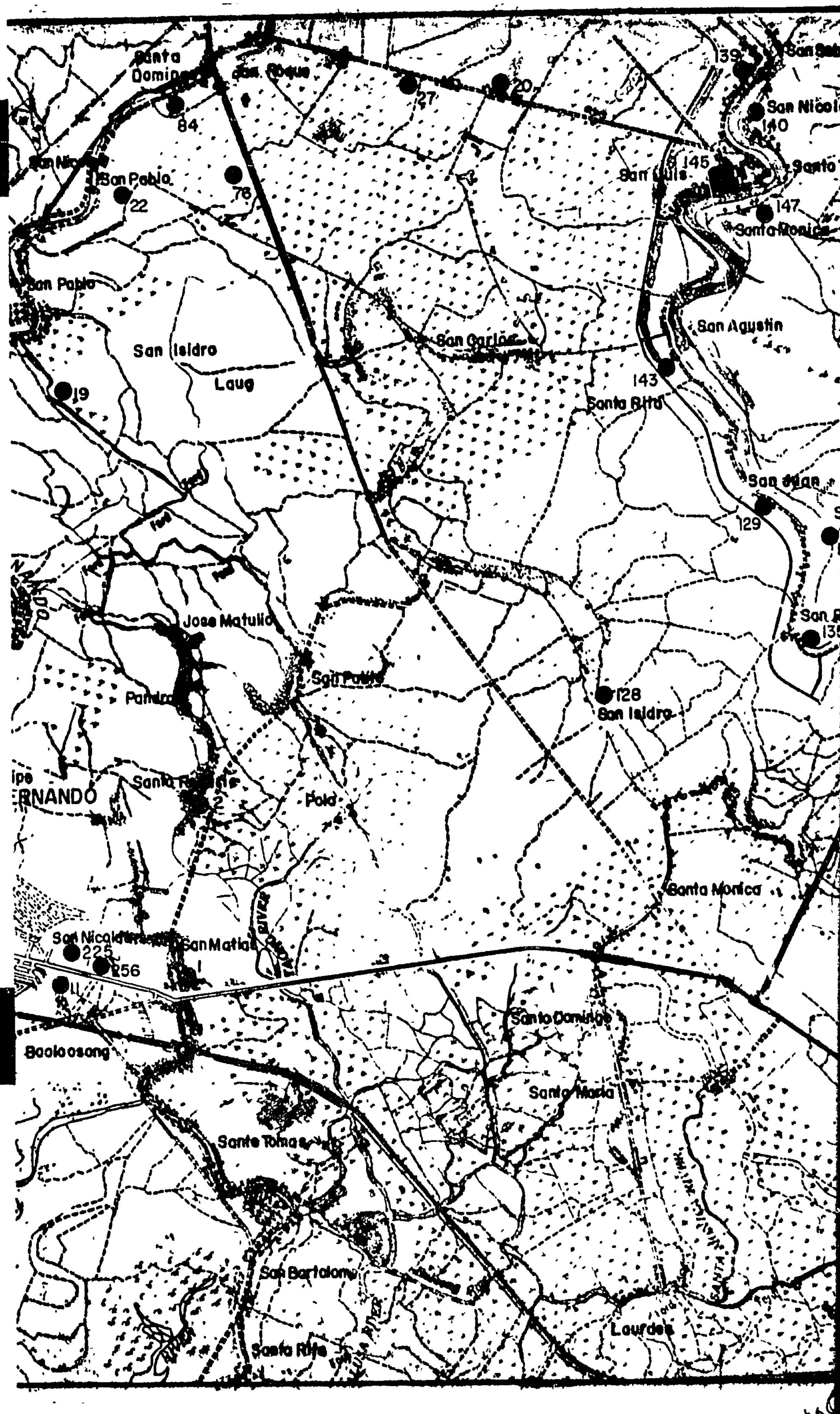
The Quaternary alluvium is an intricately interbedded sequence of clays, sands and gravels with a small amount of local cementation, probably a mixture of fluviatile, deltaic and beach deposits. Most of the beds are of limited extent. The original complex pattern of deposition and reworking has resulted in a maze of fingers and lenses of clays, sands and gravels that are difficult to trace and predict. Annex Figures VII-B-1 through VII-B-9, are stratigraphic logs of wells in the area that illustrate the situation. The stratigraphy as shown is simplified because many of the major units logged are groups of thin beds lumped under the name of the major constituent. Unfortunately, the terminology used by the drillers in describing the stratigraphic section is non-standardized and the exact nature and water-bearing characteristics of many beds cannot be determined from the logs. Occasional beds of adobe (tuff), shells and limestone are encountered in some wells as would be expected in a depositional environment at the edge of volcanic islands. The Quaternary alluvium is more than 200 meters thick in the deepest well in the San Fernando area. Total thickness at San Fernando is probably much greater.

San Fernando poblacion is situated in the flat Central Plain but the alluvial deposits are bounded or interrupted by outcrops of older rocks; the Zambales Mountains about 18 km to the west; the Sierra Madre Mountains about 30 km to the east; and the isolated volcanic peak of Mount Arayat about 12 km to the north (Figure VII-2). These older rocks were high areas sticking out of the sea (or above the plain) in which the Quaternary alluvium was deposited around and between them. The shore of Manila Bay is about 25 km south of the poblacion but fishponds and salt marshes extend very much closer. The terrain is so flat and low that the smaller rivers near San Fernando are frequently saline because of tidal effects and underflow.

<u>Wells</u>

Wells in the San Fernando area range from shallow, hand-dug wells to bored holes over 280 meters deep. Tables VII-1 and VII-2 and Annex Table VII-B-1 are summaries of pertinent records of those BPW wells, municipal wells and one NIA test well for which construction data, logs, static water levels or pumping data are available. These wells, located in San Fernando and the surrounding municipalities, were studied to evaluate the aquifer and to derive probable production well parameters.

San Jose Matino
18
Dalielis
Pangatian
Zapote
San Vicente
Santo Rosario
25
28
23
San Rafael
San Miguel
MEXICO
31
Babanilla
Masuma
Sapa Caluz Creek
Del Carmen
80
12
203
Bulach
Malpitic
Maimpis
RIVER
San Jose
San Filipe
SAN FERN
246
San Felipe
Rosario
247
248
10
San Agustin
15
Dolores
7
8
14
254
5
Lourdes
Alasas
Magliman
252
253
San Juan
San Pedro
136
Concepcion
Banlic
San Antonio
LWUA-CDM


Santa Domingo
San Roque
84
27
20
139
San Nicolas
140
San Pablo
22
78
145
San Luis
147
Santa Monica
San Pablo
San Agustin
San Carlos
San Isidro
Laug
143
19
Santa Rita
San Juan
129
San
Jose Matulid
135
San Pablo
128
San Isidro
Pandra
Santa
2
Polo
ERNANDO
Santa Monica
San Nicolas
225
256
San Matias
1
Santo Domingo
Baaloosong
Santa Maria
Santa Tomas
San Bartolome
Santa Rita
Lourdes

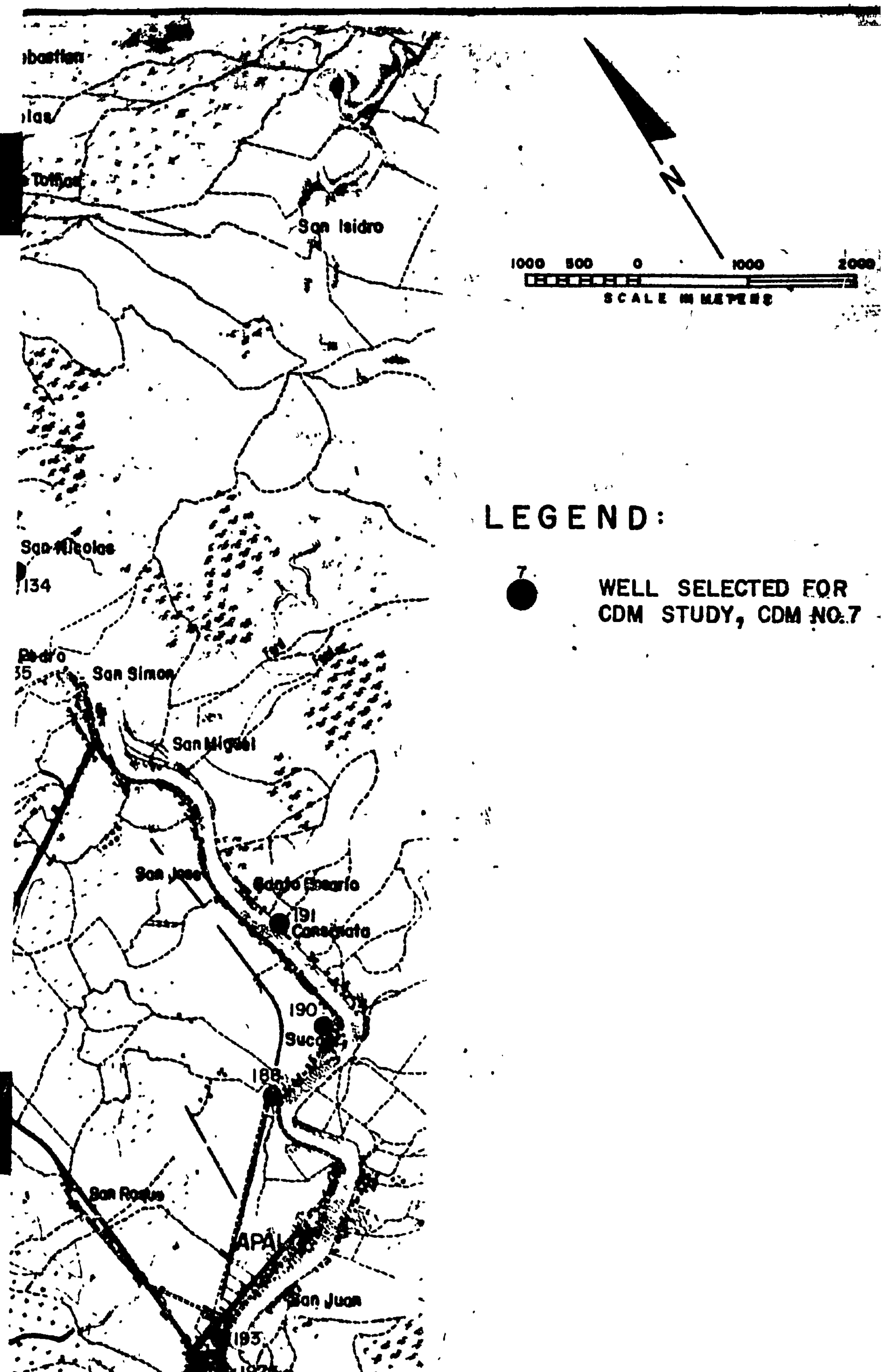


FIGURE VII-1
WELL LOCATION MAP
SAN FERNANDO WATER DISTRICT

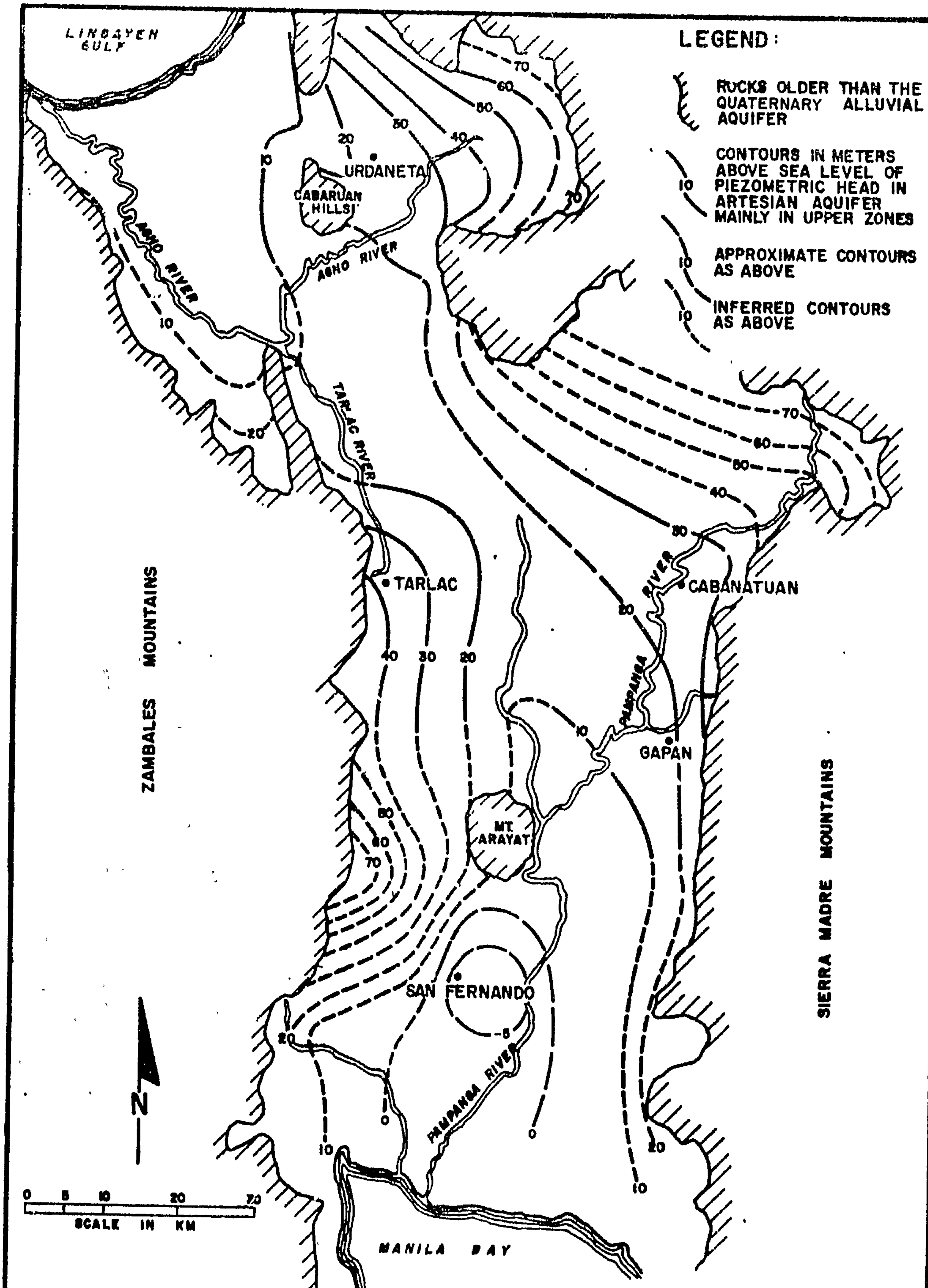


FIGURE VII - 2
GROUNDWATER CONTOURS
CENTRAL LUZON PLAIN

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

TABLE VII-1

SPECIFIC CAPACITY VERSUS DEPTH

Depth Range (m)	No. of Wells in Sample	Average Specific Capacity (lps/m)	Maximum Specific Capacity (lps/m)	Minimum Specific Capacity (lps/m)
0–10	2	1.20	2.11	0.29
10–20	22	1.33	13.57	0.04
20–30	29	0.62	3.13	0.03
30–40	21	0.90	2.53	0.14
40–50	40	0.63	3.15	0.03
50–60	21	0.47	1.22	0.07
60–70	12	0.59	2.35	0.04
70–80	4	1.09	2.53	0.30
80–90	6	1.10	1.75	0.31
90–100	2	14.38	26.25	2.52
100–150	17	3.14	33.60	0.19
150–200	6	1.53	5.25	0.32
200–250	2	1.28	1.84	0.71
250–300	1	0.96	0.96	0.96
	185			

TABLE VII-2

SPECIFIC CAPACITY VERSUS CASING DIAMETER

Smallest Casing Diameter (mm)	No. of Wells in Sample	Average Specific Capacity (lps/m)	Maximum Specific Capacity (lps/m)	Minimum Specific Capacity (lps/m)
62	3	0.67	1.27	0.25
75	1	0.25	0.25	0.25
100	85	0.68	3.19	0.03
112	42	1.28	13.57	0.10
150	28	2.85	33.60	0.07
200	2	1.44	1.84	1.03
250	1	5.25	5.25	5.25
400	1	0.69	0.69	0.69
	163			

The wells range from 6 to 284 meters deep, are cased with 60- to 400-mm casing, were constructed by percussion drilling methods, and mostly produce from either open-holes or slotted pipe at the bottom of the hole. The section tapped is generally not the only, or even the best, water-producing formation. These wells are of poor construction and design and, consequently, of low yield and low specific capacity.

Data from a large number of BPW wells and the NIA well are given in Tables VII-1 and VII-2 to show the relationships between specific capacity (rate of water production per meter of drawdown) and construction characteristics of depth and casing size.

There is no statistically significant variation in specific capacity with well depth or casing diameter. However, the 150-mm diameter cased wells have a considerably greater specific capacity than all other groups, except for the 250-mm diameter cased wells where the sample (one well) is too small to be meaningful. The implication of these data is that the specific capacity, or the productivity at a reasonable pumping level, is independent of the depth and diameter of the well (except as noted above); and furthermore, that the productivity of almost all these wells is fairly low. This is partly a result of poor design where only the bottom of the hole is productive, regardless of depth. The reason for the high average specific capacity of the 150-mm cased group is that two extremely productive wells are included in the 28 wells in this group, significantly increasing the average. The average figure for the remaining wells is not outstanding.

The two extremely productive wells are CDM No. 2, about 4 km east of San Fernando, and CDM No. 27, about 10 km northeast of San Fernando (Annex Figures VII-B-1 and ~~VII-B-8~~). The great contrast between the specific capacities of these wells and all other local wells, and the location of these wells, indicate that they produce from an abandoned buried channel of the Pampanga River. This ancient channel obviously is very permeable, but drillers' logs are so poor in descriptive terminology that the permeable strata cannot be recognized in the logs. Such channels may be fairly common but they cannot be distinguished by surface examination.

The almost uniformly poor well performance is taken to indicate a fairly poor aquifer in the area. Poor performance of most existing water supply wells in the Central Luzon Plain is expected because of poor well design and construction practices, but in many places where other wells are not better than those shown here, the NIA and a few qualified commercial drillers have been constructing excellent large capacity wells. In the case of San Fernando, it appears that the aquifer actually is only fair and is truly the limiting factor.

The NIA has drilled and tested two 250-meter deep wells (CDM-3, Annex Figure VII-B-2) at Barrio del Rosario, about 2 km northwest of San Fernando poblacion. One well was used as a test well, and the other as an observation well. The test well is of excellent design and construction, with 107 meters of well screen set according to electrical and stratigraphic log data. It produced 44.1 lps during test with a drawdown of 24 meters, a specific capacity of 1.84 lps/m. The overall transmissivity of the aquifer was computed at about 240 cumd/m, a figure indicating a fair aquifer capable of supporting wells of moderately large productivity. Annex Table VII-B-2 lists the pumping test and recovery data and Annex Figures VII-B-10 through VII-B-13 are semi-logarithmic plots of recovery and drawdown data with an analysis of aquifer transmissivity. The somewhat upcurved drawdown plot for the pumping well (Annex Figure VII-B-10) and the greater transmissivities derived from the observation well data result from partial penetration effects in an anisotropic aquifer and indicate that the specific capacity would have been slightly better if the well had been deeper.

A team of LWUA-CDM engineers ran a series of brief pumping tests on all five FER-WD production wells partly for the purposes of determining specific capacities and aquifer transmissivities at each well site. The pumping test data are presented in Annex Tables VII-B-3 through VII-B-7 and the semi-log plots of the time-drawdown data are presented in Annex Figures VII-B-14 through VII-B-18. Several plots show curves that are concave upward indicating partial penetration effects, an aquifer improving at a distance, intercepted recharge or some combination of these. Assuming that the later-time-period data are more descriptive of the aquifer as a whole, transmissivities were derived from the data. The results are shown in Table VII-3 below.

TABLE VII-3

FER-WD WELL PUMP TEST RESULTS

FER-WD Well (CDM No.)	Pumping Rate (lps)	Specific Capacity (lps/m)	Transmissivity (cumd/m)
7	27.0	3.6	199
6	19.2	1.3	136
5	7.4	0.3	45
8	6.4	0.4	27
4	10.8	1.3	100

The specific capacities of these wells are similar to those of almost all the wells described in Annex Table VII-B-1. The transmissivities derived from rate of drawdown confirm that all but one of the FER-WD wells are reasonably efficient, the 150-minute specific capacities being close to the maximum possible from aquifers with the corresponding local transmissivities. However, the specific capacity of CDM No. 6 should be much greater, considering the indicated transmissivity; and old BPW data, Annex Table VII-B-1, show that the specific capacity of this well was more than 3 times greater in 1955 than it is today. Obviously, either encrustation of the well screen or packing of fine particles around the well bore has caused well deterioration.

It will be possible to construct wells in the San Fernando area that are on the average somewhat better than the average BPW well described herein by drilling deeper, screening all permeable material encountered in the borehole, and minimizing well losses. However, except for the unlikely chance of drilling into a permeable buried river channel, the new wells will not be much better because the aquifer transmissivity is limited. For economic studies, an average aquifer transmissivity of 150 cumd/m and an average specific capacity of 1.1 lps/m are assumed. Under these conditions, wells of 30 lps production rate would show about 27 meters of drawdown and a pumping level of about 37 meters below ground level while static water levels are at existing depths.

Aquifer

Within the projected service area of the FER-WD, the Quaternary alluvium is a productive artesian aquifer system. The thickness of this aquifer is unknown but it appears to encompass most of the alluvium which is at least 280 meters thick locally and is assumed to be much thicker. This artesian aquifer system may include some older underlying beds at depth and may be contiguous with the aquifer system in the surrounding hills.

The aquifer consists of lenses of water-bearing material, ranging from fine sands to gravels, deposited in a complex and random pattern and confined by equally complex clay lenses. The well logs indicate clayey beds at the surface in essentially all cases, which inhibit direct recharge in the San Fernando vicinity.

The aquifer is anisotropic and will act as a semi-confined aquifer in that early response to pumping will be in the artesian aquifer range, that is, with a small storage coefficient; however, as piezometric head falls and various sand beds are dewatered, response will be in the unconfined (water table) aquifer range with a very much greater storage coefficient. This effect will tend to slow the general lowering of the aquifer piezometric levels (or water table) that is already in progress, even with the limited current pumping withdrawals.

Overall aquifer transmissivity in the San Fernando area is estimated to average about 150 to 200 cumd/m, which is much less than the transmissivity in most of the Central Plain. An early storage coefficient of 0.002 is derived from the only complete pumping test in the San Fernando area (Annex Figures VII-B-12 and VII-B-13), but long-term storage coefficients should range between 0.1 and 0.2.

Recharge, Discharge and Flow of Groundwater

Recharge to this aquifer is through infiltration from direct precipitation and from streams into the exposed permeable beds along the edge of the foothills west and north of San Fernando. Initially, the recharge water is under water table conditions but becomes confined upon moving below the clay beds, as shown by historically free-flowing wells in the San Fernando area. Additional recharge may reach the Quaternary alluvium from infiltration of precipitation in the mountains and foothills to the west through transfer from older permeable beds where the alluvium abuts these beds along the buried edge of the hills. The sandy deposits of the Pampanga River channel probably extend through the surface clays. The current shape of the contours of the piezometric surface, Figure VII-2, and the current relative elevations of this surface and river levels indicate that recharge also now comes from the Pampanga River near San Fernando, and a small amount probably comes from the smaller rivers and swamps in this area as well. In the past, when groundwater levels were higher, groundwater discharge into the local rivers and swamps undoubtedly occurred instead of the present-day reversed conditions.

Before large-scale artificial withdrawal of water (pumping from large-capacity wells), the local and regional groundwater balance was in a state of dynamic equilibrium. In the San Fernando area, there was little local recharge because of the widespread surface clays and the near-surface or above-surface piezometric levels. There was a large natural discharge into the local rivers and swamps where groundwater piezometric levels were above ground levels. The remaining groundwater underflow discharged into Manila Bay. Thus the preexisting system was essentially one of groundwater underflow entering the San Fernando area from distant recharge sources to the northwest, some discharging to the surface locally and the remainder flowing into Manila Bay to the south.

All well water produced must come from one or more of a limited number of sources; groundwater storage, increased recharge, or diverted discharge. The natural state is normally one of equilibrium as described above with total recharge equal to total discharge and stable groundwater storage. When a well first begins to operate, all the pumped water comes from local groundwater storage (immediately surrounding the well) as a result of the decreased pressure in the well caused by pumping. This zone of decreased pressure (or lowered piezometric head) spreads radially from the well as stored groundwater flows from the aquifer to the well, and it continues to spread until the area of depressed piezometric levels causes either an increase in recharge (local or distant) or a decrease in pre-established groundwater discharge (local or distant) equal to the pumping rate of the well. When this occurs, a new equilibrium will be established with no further depletion of groundwater storage. If the increased recharge or diverted discharge (or combination thereof) is local, equilibrium will be quickly established with minimal lowering of the piezometric surface; but if they are distant, equilibrium will be long delayed resulting in a widespread and large depression in groundwater levels. If no sources of increased recharge or diverted discharge large enough to equal the pumped withdrawal rate can be tapped, then the groundwater levels will continue to drop until the well becomes inoperative or the aquifer is depleted.

In the case of San Fernando, it is obvious that pumped discharge in the area has been exceeding any diverted underflow, diverted discharge or induced additional local recharge for many years. As a result, groundwater storage has been increasingly depleted and, consequently, the groundwater piezometric level has been lowered. Table VII-4 illustrates the situation locally and near San Fernando Poblacion.

TABLE VII-4

STATIC WATER LEVELS NEAR SAN FERNANDO POBLACION
(Meters Above (+) Or Below (-) Ground Level)

Well	SWL - 1953 to 1959	SWL - 1977
CDM-4	Above ground level	- 8.5
CDM-5	- 1.5	- 9.1
CDM-6	+ 2.1	- 8.2
CDM-7		-10.7
CDM-8		- 9.1
CDM-11	- 3.4	
CDM-13	- 3.7	
CDM-14	- 0.0	
Average	- 1.0 (approximate)	- 9.1

Thus, the static water level has declined over 8 meters in about 20 years even at the present rate of pumping. Most of this decline probably has occurred recently. The rate of pumping is expected to increase steadily in the coming years as population increases and industrial, commercial and agricultural demand likewise increases.

The present groundwater piezometric levels in the Central Plain are shown in Figure VII-2. In the San Fernando area, these levels are already below sea level and, as groundwater withdrawals continue and increase, these levels will decrease further. The major danger of this trend is that a groundwater gradient has already been established from Manila Bay to the San Fernando area. Groundwater flow has undoubtedly reversed its historical path and sea water is flowing into the aquifer from the outcrop area of the aquifer under the sea toward the San Fernando area. The gradient is still gentle and the undersea outcrop area is a long way from San Fernando so that many years probably will elapse before salinization effects are noted.

Manila provides an example of the process involved although the saline groundwater flow path from Manila Bay is shorter to Manila than it is to San Fernando. Originally, groundwater under Manila was non-saline and static water levels were above sea level. Today, the upper groundwater is saline to depths of over 150 meters and the static water levels are deeper than 100 meters in places. Wells are now being drilled so as to produce the water in the aquifer that is still fresh at depths of over 200 meters.

The regional situation also is illustrated by the contour map of the groundwater piezometric surface of the Central Luzon Plain (Figure VII-2). This shows the source of the groundwater underflow to the northwest of San Fernando and the ultimate discharge of the groundwater underflow to Manila Bay south of San Fernando. However, the groundwater gradient becomes so flat in the middle of the Central Luzon Plain that all of the groundwater flowing from the east, north and west cannot be flowing into Manila Bay. Much, if not most, of the groundwater underflow into the Pampanga River basin must rise to the surface in seeps into the swamps and streams of the southern Central Plain where the artesian head is above the ground surface. All of this water is lost by non-beneficial evapo-transpiration and surface runoff into the Bay. It should be noted that piezometric levels shown are generally characteristic of the upper part of the aquifer and higher levels may exist in the lower part of the aquifer in some areas. These levels are derived from data in Annex Table VII-B-1, from other BPW well data, from CDM field observations, and from NIA observation well data.

In the vicinity of San Fernando, the piezometric levels range from sea level to more than 10 meters below sea level. Such areas were once, when groundwater piezometric levels were higher, areas of groundwater seepage and loss into river channels and swamps. They now are areas of recharge to the aquifer wherever the surface layers are permeable enough to permit infiltration, and thus add somewhat to the available groundwater. The major significance of this area of depressed groundwater levels is that it acts as a sink or drain and diverts groundwater underflow from north and south of San Fernando into the San Fernando area where it can be pumped for municipal use. Unfortunately, this sink also induces saline recharge from the sea.

Current recharge to the aquifer is largely restricted to the edges where infiltration and transfer from surrounding areas can occur, as has been previously noted. Neither current recharge nor future additional recharge induced by pumping can be quantified with existing data, but groundwater flow is to the southeast at a gradient of about 0.006 in the San Fernando area. The average overall transmissivity of the aquifer in this area is estimated at 150 cumd/m or more. According to Darcy's Law of Flow:

$$Q/\text{km (of aquifer width)} = T \times G \times 1000 \text{ m/km}$$

Where:

Q = Groundwater underflow (cumd)

T = Aquifer transmissivity (cumd/m)

G = Gradient of the piezometric surface

Or:

$$Q/\text{km} = 150 \text{ cumd/m} \times 0.006 \times 1000 \text{ m/km} = 900 \text{ cumd/km (minimum estimate)}$$

The underflow of groundwater can be used to roughly determine the groundwater available for exploitation. The FER-WD average daily demand is projected to be about 14,400 cumd in 1990 and 29,600 cumd in 2000. To obtain all this water from underflow would require diverting and capturing all the underflow in a band about 16 km wide by the year 1990 and 33 km wide by the year 2000. Less than this computed amount of underflow would have to be captured because induced additional recharge, as noted previously, is supplying some of the water to be pumped. Although projecting accurate future pumping levels would require producing a model based on much more than the available data, it is apparent that diverted groundwater underflow and induced additional local recharge are not supplying even the current demand for groundwater in the San Fernando area and the decline in levels resulting from depletion of groundwater storage will continue and increase even if the San Fernando area were the only consumer.

Unfortunately, there are numerous other fairly large towns in the region that are expected to grow at the same rate as San Fernando and ultimately to consume the same per capita water quantities. The total domestic, commercial and industrial water requirements will be several times that projected for San Fernando. Groundwater will undoubtedly be used to meet these requirements.

In addition, the area is short of irrigation water and, considering the fair underlying aquifer, large-scale groundwater irrigation may be introduced. Assuming that one meter net (a low estimate) of irrigation water will be required o supplement rainfall, an annual average of about 2,700 cumd of irrigation water would be required per 100 hectares (one sqkm) of irrigated land. The full year 2000 water requirement for FER-WD would be needed to support 1,000 hectares (10 sqkm) of irrigated land. If groundwater irrigation is not restricted or prohibited, very rapid lowering of the piezometric surface and salinization of the aquifer will occur soon, making the aquifer unfit to supply the local communities long before it would otherwise occur.

With available data, it is not possible to predict groundwater levels at various future dates with any certainty; but, as more data on aquifer characteristics and response become available, predictions should be made based on model studies. One favorable factor is that as groundwater piezometric levels drop below the clayey surface beds, the storage coefficient of the aquifer will increase greatly and more groundwater will be available from storage, thus slowing the decline in groundwater levels.

The implications are that the FER-WD must obtain firm water rights to its long-range requirements from the National Water Resources Council and introduce a groundwater monitoring and study program for planning purposes. These acquired rights must be protected from encroachment by other users. It is unfortunate that in the FER-WD area, overproduction of groundwater is inevitable and is already occurring, and further, that the overproduction will result not only in higher production costs but also in salinization of the groundwater that will limit or also destroy its usefulness. Nevertheless, simple economic analysis indicates that groundwater is the only practical, economical water source that the FER-WD and its consumers can afford, all other sources being much more expensive. Eventually an alternative will have to be developed, but probably not until after the year 2000.

Well Design and Drilling Programs

A general design for an efficient production well for San Fernando can be developed from available data. Such a design is illustrated in Figure VII-3. For greatest efficiency, in order to avoid excessive drawdown and to minimize operating costs, these wells should be drilled so as to utilize the full aquifer potential and to minimize losses. All stratigraphic zones down to a depth of 300 meters or more that are indicated as productive by the electric and stratigraphic logs should be screened, because in an anisotropic aquifer such as

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this, the specific capacity will increase greatly as the percentage of total permeable section screened increases. The use of continuous wire wrapped screen will aid development and reduce hydraulic head losses. It is anticipated that such wells should produce 30 lps at an average of about 27 meters of initial drawdown, with the poorest wells at about 40 meters of initial drawdown. This is believed to be conservative and is used for preliminary design and estimation purposes because reliable data are very limited. The static water level at San Fernando Poblacion is now about 10 meters below ground level, and it is expected to continue declining to indefinite depths. Therefore, the pumphousing casing should be a minimum of 75 meters long, to accommodate future static water levels plus drawdown, and should be as long as possible without restricting the provision of screen opposite permeable formation zones. The wells should be located so as to minimize the cost and operational complexity of the distribution system, taking into account that the spacing between wells should be as great as practical (preferably an average of 1 km or more) to minimize drawdown interference. It should be recognized that few, if any, existing local private well drilling firms have the necessary experience, equipment and ability to design and construct rotary-drilled wells of good quality without external professional supervision.

The first wells constructed under the drilling program should be carefully tested and the results from them used to modify the design of succeeding wells. They should be pumped intensively for several years and the aquifer response monitored. The data can then be used as guides for further development of the well system which probably will consist of 30 lps wells spaced about 1 to 2 km apart. Wells designed to produce 30 lps may be pumped at a greater rate if the well is unexpectedly good and the local consumption requires greater production. However, this preliminary estimate must be revised and phased into the overall groundwater development plan for the San Fernando area. Any future development of groundwater for irrigation must be taken into consideration in the design of FER-WD wells.

<u>Induced Infiltration Wells</u>

In anticipation of a possible significant overexploitation of the deep aquifer, making total reliance on deep wells undesirable, the design and use of relatively shallow, induced infiltration wells drilled in the sands and gravels of the local river floodplains were considered If such wells were practical, they could probably produce as much water at shallower pumping levels as the deep wells discussed previously; and, since production would quickly be replaced by induced recharge from the rivers, total well field production would be limited only by the low flow in the rivers, conflicting rights to this water, and the quality of the river water.

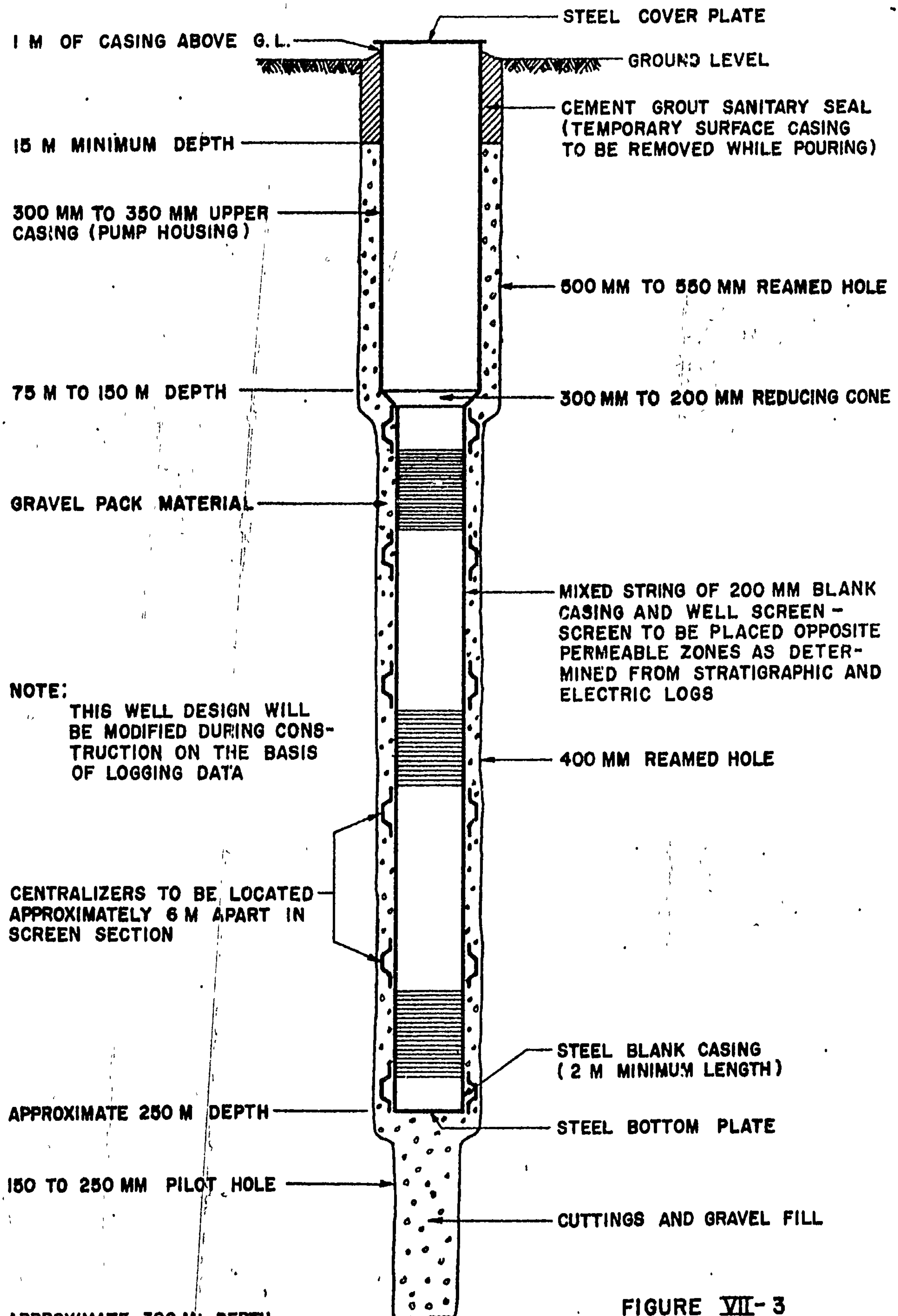

FIGURE VII-3
GENERAL DESIGN
GRAVEL PACKED WELL
ROTARY DRILLED
SAN FERNANDO WATER DISTRICT

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

Such wells are not practical in the San Fernando area for two reasons. Firstly, the water of the smaller rivers and of the lower reach of the Pampanga River is frequently saline; and, because such wells essentially produce filtered river water, the water produced would be saline. Secondly, all of the rivers are incised in narrow channels in the normal sediments of the Central Plain and consequently, lack the broad, sandy floodplain deposits necessary for the successful operation of induced infiltration wells.

Monitoring

Basic planning for overall exploitation of groundwater resources in the San Fernando area will be based on the limited data currently available and those derived from tests of the first production wells. However, records of water production from all large-capacity wells and of aquifer response to pumping are necessary to refine the preliminary aquifer parameters and to revise the planning as necessary in order to avoid the danger of overexploitation or the waste of underexploitation. The FER-WD should monitor the performance of each of their production wells and observation wells to provide data and information for water district use and for distribution to other agencies for overall planning and control. In turn, other Central Luzon water districts and other groundwater users should monitor their operation and provide appropriate data to FER-WD.

Each production well should have facilities for measuring the total amount of production or rate of production, times of operation and water levels. Routine monthly observations of static and pumping water levels should be recorded and daily records of pumping kept. Water samples for bacterial analysis should be collected monthly and for chemical analysis, semi-annually. It would also be desirable to monitor static water levels in several observation wells located within the area spanned by FER-WD wells but far enough from any well to minimize local drawdown effects. Similar routine static water level measurements should be taken in numerous observation wells surrounding the well field at a distance.

The data from this monitoring program will provide better aquifer parameters, indicate the magnitude of recharge, give early warning to FER-WD of deterioration in water quality, well efficiency or pump performance so that remedial action can be taken, and indicate any unforeseen decline in regional water levels so that individual well yields (which affect local pumping levels) and design and spacing of future wells can be adjusted as necessary. For these purposes, copies of all FER-WD well monitoring data should be analyzed routinely by FER-WD (if it has competent staff for such analysis) or by some associated agency competent to perform such analysis.

Summary of Groundwater Resources

San Fernando is located over a fairly good, widespread, relatively uniform aquifer that probably can supply all its projected water demands past the year 2000 from deep wells, each producing 30 lps or more. However, the regional drawdown of groundwater levels resulting from such pumping cannot be accurately quantified because available data on aquifer parameters and recharge are insufficient. Other data will become available from pumping tests of the new production wells and from the monitoring program of production and observation wells. Although the exact rate of groundwater level decline is currently unpredictable, the decline will continue and static water levels will become much deeper than they are today. Eventually, salinization will result and another source will have to be found. The aquifer probably will continue to provide water suitable for FER-WD use until beyond the year 2000, although some aquifer zones (probably shallow zones) may become salinized and deeper zones that are not currently exploited will have to be put into service to provide the required fresh water. Future well design and well field planning must be modified on the basis of the new data to maintain local groundwater production for long-term use.

Induced infiltration wells in the area are not technologically feasible.

If the intensive use of groundwater for irrigation eventually occurs in the San Fernando area, overexploitation of the aquifer will result, and groundwater salinization will occur much earlier than expected.

C. SURFACE WATER RESOURCES

A brief economic analysis shows tha surface water is not competitive with groundwater in the San Fernando area at present because of the high cost of treating and transporting the surface water. However, in the distant future, groundwater may not be usable because of salinization resulting from overpumping unless strict control measures are taken. A brief review of potential surface water sources is presented.

There are a number of small rivers close to San Fernando, including the San Fernando River, which run through the poblacion. These rivers essentially are drains for the swamps and low-lying lands in the area. The water of these rivers is too saline for municipal water supply use and the minimum flows are too low for the FER-WD requirements in the year 2000.

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The major Pampanga River flows about 9 km east of San Fernando Poblacion with a minimum recorded flow of over 850,000 cumd, almost 30 times the FER-WD requirements for the year 2000. The lower reaches of the river are made saline by intrusion of sea water from Manila Bay. A water intake for FER-WD use would have to be located upstream of the reach of the salinization effect which probably extends beyond the closest point on the river to San Fernando. It is likely that the water quality of the Pampanga River will deteriorate upstream of the sea water intrusion as a result of drainage contaminated with increasing quantities of agricultural chemicals and other pollutants; but, it is unlikely that such contamination will become serious enough to make the water unfit for use if reasonable control is exercised.

Another possible source of surface water supply is the rivers of the mountains 20 km or more to the west of San Fernando. While it is likely that none of these rivers alone have a minimum flow sufficient to meet the FER-WD requirements for the year 2000, a combination of them could supply this requirement. These streams are located at much higher elevations than San Fernando and so pumping costs would be minimized. However, these streams are widely used for irrigation as illustrated by conditions on the Porac River at Porac Irrigation Dam near Del Carmen, Floridablanca. In 1967, the minimum Porac River flow was 21,600 cumd a short distance upstream of the dam and 6,050 cumd a short distance downstream of the dam. It appears that the only potential water source for FER-WD from these streams would be a combined irrigation - municipal water supply storage dam project.

D. WATER QUALITY OF POTENTIAL SOURCES

Water samples were taken from many of the sources, both groundwater and surface water, discussed previously. Chemical analyses of these samples were performed to determine the water quality with respect to potability and treatment requirements. The results of these analyses are shown in Tables IV-3 and VII-5, and are briefly discussed below.

Groundwater

Since groundwater essentially passes through a filtration process while flowing through a granular aquifer (such as in the FER-WD area), and is not exposed to surface pollution, color and turbidity or suspended solids are usually not present. For this reason, unless other deleterious substances (such as excessive hardness, dissolved gases or dissolved iron) are present, treatment other than disinfection is generally not required.

The results of water analyses of samples taken from the five existing FER-WD wells are shown in Table IV-3. All of the well waters analyzed fall below the "excessive" limits of the Philippine National

TABLE VII-5

WATER QUALITY TEST RESULTS
POTENTIAL SOURCES
SAN FERNANDO WATER DISTRICT

Test	Unit	Permissible Limits	San Fernando River San Fernando	Cailugan River Bo. Sta. Catalina
Physical				
Color	APHA	15	65***	20***
Turbidity	FTU	5	20***	13***
Total Dissolved Solids*	mg/l	500	1,560***	6,240***
Conductivity	Micromhos/cm		2,400	9,600
Chemical				
pH		7-8.5	7.35	7.40
Total Alkalinity	mg/l $CaCO_3$		320	140
Phenolphthalein Alkalinity	mg/l $CaCO_3$		0	0
Total Hardness	mg/l $CaCO_3$	400****	321	1,812 ***
Calcium	mg/l Ca	75	54	114**
Magnesium	mg/l Mg	50	45	366***
Total Iron	mg/l Fe	0.3	0.2	0.18
Fluoride	mg/l F	1.5	0	0.38
Chloride	mg/l Cl	200	613***	3,883***
Sulfate	mg/l SO_4	200	27	207**
Nitrate	mg/l NO_3	50	17.71	5.54
Manganese	mg/l Mn	0.1	2.2***	0

*Calculated as 65% of conductivity.
**Exceeds permissible limits set by the Philippine National Standards for Drinking Water.
***Exceeds the excessive limits set by the Philippine National Standards for Drinking Water.
****Limit inferred from limits of individual metals causing hardness.

Standards for Drinking Water, and below the "permissible" limits in all respects except for iron content in the Barrio San Pedro well. However, the "permissible" limits are not prohibitive but only serve as guidelines, and in this case where the iron content is not extremely high and where no known complaints about the water have been received, the water is acceptable for domestic use without extensive treatment. The water that will be produced from future FER-WD is expected to be similar to the tested well waters for many years; but with long continued pumping and a water table already below sea level and continually declining, at least some aquifer zones will eventually begin to produce salinized water as a result of sea water intrusion.

The conductivities of four samples from shallow, handpump wells located very close to the Pampanga River were also measured. The results are presented in Table VII-6.

TABLE VII-6

CONDUCTIVITIES OF HANDPUMP WELL WATER

Well Location	Approximate Distance Upstream of River Mouth (km)	Conductivity of Sample (micromhos/cm)	Approximate Total Dissolved Solids (mg/l)
Poblacion Apalit	24	1,000	650
Poblacion San Simon	30	750	490
San Nicolas San Simon	32	500	325
Poblacion San Luis	36	550	360

The deep groundwater in the area has a conductivity of about 400 micromhos/cm as shown in Table IV-3. The high conductivities of the shallow groundwater at Apalit and San Simon indicate considerable saline infiltration and, therefore, indicate that saline water intrusion occurs in the Pampanga River up to this point for significant periods of time. The lower salinities upstream indicate that there is little or no saline water in the Pampanga River above San Simon. These results confirm that the small rivers in the San Fernando area are very saline and that the Pampanga River is generally non-saline. However, the evidence of saline groundwater in shallow wells along the banks of the Pampanga River from San Simon south indicates that this river carries saline water in its lower reaches at some time of the year, probably low flow, high tide periods. Thus, if the Pampanga River is ever chosen as a surface water source for FER-WD, or any other municipal water system, a long-term salinity monitoring and study program should be undertaken at the proposed intake site before final intake site selection is made.

The low conductivity of the Candaba Swamp water, in contrast to the saline swamps south of San Fernando, is in agreement with the theory that many swamps in the Central Plains result from a combination of poor drainage and groundwater seepage.

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ANNEX VII-B

GROUNDWATER RESOURCES

ANNEX TABLE VII-B-1

WATER WELL DATA SUMMARY
SAN FERNANDO WATER DISTRICT

CDM Well Number	BPW Well Number	Location	Nominal Diameter (mm)	Depth in Ground Surface in Meters: Total	Cased	Static Water Level	Pumping Water Level	Test Yield (lps)	Specific Capacity (lps/m)	Year Completed
1	7975	San Matias, Sto. Tomas	150	43.3		- 7.6	- 9.1	0.63	0.42	1955
2		Bo. Sta. Rosario, Sto. Tomas	150	144.8		0	- 1.5	50.4	33.6	1970
3	NIA GL-35-46	Bo. Del Rosario, San Fernando	350 200	250	60 246	-11.0	-35.0	44.1	1.84	1977
4	10862	Bo. San Pedro, FER-WD San Fernando	200	218.6		Flowing Ground Level (1958) - 8.5 (1977)	-17.9 (1977)	11.9 (1977)	1.26 (1977)	1958
5	6288	Capitol Site, Sto. Niño FER-WD, San Fernando	200	171.0		- 1.5 - 9.1 (1977)	-13.7 -32.9 (1977)	12.6 7.4 (1977)	1.03 0.31 (1977)	1955
6	5769	Dolores, FER-WD, San Fernando	200	220.4		+ 2.1 - 8.2 (1977)	-23.1 (1977)	12.6 19.2 (1977)	1.29 (1977)	1953
7		Poblacion, FER-WD San Fernando				-10.7 (1977)	-18.2 (1977)	27.0 (1977)	3.61 (1977)	
8		Lourdes, FER-WD San Fernando				- 9.1 (1977)	-25.1 (1977)	6.4 (1977)	0.40 (1977)	
9	436910	Bo. Saguing, Sn. Fernando	112	18.3		- 4.6	- 6.7	0.5	0.24	1969
10	426042	Sn. Agustin, Sn. Fernando	100	63.4		- 3.7	- 6.1	0.63	0.26	1961
11	6652	Bo. San Nicolas, San Fernando	150 100	47.0		- 3.4	- 6.1	0.94	0.35	1954
12	425921	Bo. Bulaon, San Fernando	100	18.0		- 3.0	- 3.7	0.44	0.63	1959
13		Capitol Site, San Fernando		83.8		- 3.7	- 5.5	3.15	1.75	1953
14	425911	Dolores, Sn Fernando	150	198.2		0	-17.4	13.5	0.78	1959
15	436920	Bo. San Isidro, San Fernando	100	18.3		- 4.3	- 5.5	0.63	0.52	1969

ANNEX TABLE VII-B-1 (Continued)

CDM Well Number	BPW Well Number	Location	Nominal Diameter (mm)	Depth in Ground Surface in Meters				Test Yield (lps)	Specific Capacity (lps/m)	Year Completed
				Total	Cased	Static Water Level	Pumping Water Level			
16	43676	Bo. Pangatlan, Mexico		76.2		- 3.0	- 6.1	0.94	0.3	1969
17	436812	Bo. Anao, Mexico		100.6		- 3.6				1969
18	537205	Bo. San Patricio, Mexico	112	68.6		- 7.6	- 8.5	0.94	1.04	1972
19	43699	Bo. San Lorenzo, Mexico		87.5		- 2.1				1969
20	9715	Sta. Maria, Mexico	150	29.6		- 1.8	- 4.6	0.63	0.22	1955
21	43696	San Juan, Mexico		85.4		- 2.1				1969
22	9713	San Pablo, Mexico	150	48.8		- 2.1	- 3.7	0.94	0.59	1955
23	426151	Bo. Sto. Rosario (School Site) Mexico	100	70.1		- 1.2	- 1.8	0.63	1.05	1961
24	436811	Bo. Anao, Mexico	150	100.6		- 2.4	- 6.1			1968
25	18047	Bo. Sto. Rosario, Mexico	100	65.9		- 1.8	- 2.7	0.63	0.7	1961
26	43694	San Juan, Mexico	112	33.5		- 3.0		1.26		1969
27		Bo. Sta. Maria, Mexico	150	98.2		- 0.9	- 2.1	31.5	26.25	1968
28	43689	Bo. Cawauan, Mexico	150	91.5		- 0.6				1968
29	6654	Bo. Sto. Rosario, Mexico	100,150	66.5		0	- 0.4	0.94	2.35	1954
30	43681	Bo. Anao, Mexico	150	91.5		- 0.9				1968
31	5743	Poblacion, Mexico	100	106.1		- 2.4		1.26		1953
32	426273	Basa Air Base II, Florida Blanca	150	155.5		-13.4	- 4.3	9.45	0.32	1962
33	15232	Bo. Sto. Niño, Paguiruan, Florida Blanca	112	35.1		- 4.6	- 5.5	0.76	0.84	1957
34	15233	Bo. San Jose, Florida Blanca	112	14.9		- 3.0		0.5		1957
35	10860	Poblacion, Florida Blanca	250	160.1		- 1.8	- 3.0	6.3	5.25	1957
36		Bo. Calantas, (School Site), Florida Blanca		23.8		- 6.1	- 15.2	0.44	0.05	1969
37	15233	Bo. M. Jose, Florida Blanca		15.2		- 0.9	- 3.0	0.63	0.3	1969
38	19283	Bo. Sta. Monica, F. Blanca		29.0		- 4.6	- 7.6	0.63	0.21	1969
39	17184	Bo. Monacat, Florida Blanca	100	26.5		-10.7	- 19.8	0.44	0.05	1957
40	5305	Basa Air Base, F. Blanca		106.7		-14.0	- 16.8	5.17	1.85	1951
41	7974	Bo. Calantas, F. Blanca		21.3		- 9.1	- 10.7	1.07	0.67	1961
42	5882	Basa Air Base, F. Blanca	400	115.2		- 9.1	- 14.6	3.78	0.69	1954
43	6793	Town Plaza, F. Blanca	100	19.5		- 3.0	- 10.7	0.32	0.04	1953
44	7976	Valdez, Florida Blanca	150	16.8		- 6.1	PWL	0.63		1955
45	7977	Fortuna, Florida Blanca	150	12.2		- 1.5	- 3.6	0.63	0.3	1955

ANNEX TABLE VII-B-1 (Continued)

CDM Well Number	BPW Well Number	Location	Nominal Diameter (mm)	Depth From Ground Surface in Meters: Total	Cased	Static Water Level	Pumping Water Level	Test Yield (lps)	Specific Capacity (lps/m)	Year Completed
68	6634	Bo. Sta. Cruz, Lubao	100	76.8		+ 1.5		0.94		1954
69	10858	Lubao	250	284.1		+ 4		Flowing 9.45		1957
70	19304	Sta. Barbara, Lubao	60	73.8		+ 0.3		0.32		1962
71	43635	Bo. San Nicolas, Lubao	200	79.6		+ 0.6		Flowing 0.5 Flowing		1963
72	426012	San Juan, Sta. Ana	100	56.4		- 1.8	- 2.7	0.95	1.06	1960
73	5782	San Joaquin, Sta. Ana	100	48.2	47.6	- 1.2	- 4.6	0.09	0.03	1953
74	14593	Bo. San Isidro, Sta. Ana	100	43.6	37.5	- 1.5	- 3	0.63	0.42	1957
75	426162	Sapang Putut, Sta. Ana	112	58	54.6	- 1.5	- 2.4	0.63	0.7	1961
76	19355	Sn. Roque, Sta. Ana	100	48.8	48.8	- 3	- 4	0.63	0.63	1970
77	16818	Bo. Sn. Pedro, Sta. Ana	100	68.6	65.5	- 3.6	- 5.5	0.94	0.49	1957
78	16819	Bo. Santiago, Sta. Ana	100	51.2	50.6	- 4.9	- 5.8	0.88	0.98	1957
79	53701	Bo. San Isidro Sta. Ana	200	67.1	61	- 3.6				1970
80	426011	NPC, Bo. San Jose, Mexico	100	117.4	111.3	+ 1.1	- 4.6	2.5	0.44	1960
81	426161	Bo. Sta. Maria, Sta. Ana	100	58	57	- 2.13	- 2.7	0.4	0.7	1961
82	16817	Sta. Maria, Sta. Ana	100	44.2		- 4.6	- 7.6	0.63	0.21	1969
83	6639	Bo. Sta. Maria, Sta. Ana	100	68.6	41.2	- 3	- 9.1	0.94	0.15	1954
84	14594	Bo. San Roque, Sta. Ana	100	50.3	48.8	- 0.3	- 1.5	0.94	0.78	1957
85		Irrigation Well, Bo. Santiago, Sta. Ana	250, 200, 150	131.1		- 1.2				1968
86	4592	Bo. Sta. Lucia, Sta. Ana	60	29	10.4	- 2.1	- 2.7	0.76	1.27	1962
87	14592	Sta. Lucia, Sta. Ana	112	30.5	30.5	- 2.4	- 3	0.94	1.57	1957
88	16816	Bo. San Joaquin Sta. Ana	100	48.2	46.3	- 2.1	-11.6	1.1	0.12	1957
89	13164	Bo. San Isidro, Sta. Rita	112	20.1	17.1	- 0.61		0.94		1956
90	13163	San Juan, Sta. Rita	150	23.8	21.3	- 1.5	- 2.1	0.63	1.05	1956
91	17045	San Juan, Sta. Rita	150	73.2	59.4	Flowing		Flowing 2.5		1956
92	17046	Bo. San Jose, Sta. Rita	100	48.5	43	0	0.3	0.5	1.67	1958
93	436917	Bo. Sta. Monica, Sta. Rita	100	30.5	28.3	0		0.63		1969
94	15225	San Agustin, Sta. Rita	112	39	37.3	-1.5	-1.8	0.76	2.53	1956
95	15229	Bo. Sn. Basilio Elem. Sch.	112	20	20	-3.6	-3.9	0.5	1.67	1957

CDM Well Number	BPW Well Number	Location	Nominal Diameter (mm)	Depth From Ground Surface in Meters: Total	Cased	Static Water Level	Pumping Water Level	Test Yield (lps)	Specific Capacity (lps/m)	Year Completed
96	15226	Bo. San Vicente, Sta. Rita	100	42.7	42.7	- 6.4	- 7.6	0.31	0.26	1969
97	15224	*San Isidro Elem. Sch.	112	33.8	30.5	- 1.2	- 1.5	0.63	2.1	1956
98	15231	*Bo. Becuran Elem. Sch.	112	17.7	17.7	- 3	- 3.6	0.5	0.83	1957
99	15228	*Sta. Monica Elem. Sch.	112	14.6	12.8	0	- 1.5	0.31	0.21	1957
100	15227	*San Juan Primary Sch.	112	19.5	18.3	- 1.5	- 1.8	0.76	2.53	1957
101	17047	San Matias, Sta. Rita	112	19.8	1.5	- 0.9	- 1.5	0.63	1.05	1958
102	15230	*Dila Dila Comm. Sch.	112	20.4	15.8	- 4.6	- 5.5	0.31	0.34	1957
103	17044	San Francisco, Minalin	100	94.5	85.4	+ 0.46		0.94		1958
104	17043	Sta. Catalina, Minalin	100	82	76.5	4.6	- 5.2	0.94	1.57	1958
105	17042	Sto. Rosario, Minalin	100	82	76.8	+ 0.3		1.9		1957
106	10359	Dawe, Minalin	150	57	56.7	0	- 5.5	0.63	0.11	1956
107	10357	Bo. Mañango, Minalin	112	56.7	54.6	- 4.2	- 6.4	0.63	0.29	1956
108	10358	Bulac, Minalin	150	41.5	41.5	- 2.4	- 4.6	0.63	0.29	1956
109	10360	Bitukang Manok, Minalin	150	54.9	54	- 0.3	- 5.5	0.63	0.12	1956
110		San Nicolas, Minalin		89.6		0	- 6.1	1.9	0.31	1962
111	10361	Palanan, Minalin	150	38.1	35.7	- 1.8	- 5.5	0.63	0.17	1956
112	5808	San Pedro, Minalin		6.1		- 0.9	- 1.8	1.9	2.11	1962
113	42612	Dawe, Minalin	100	83.2	51.2	+ 0.6	- 1.5	1.3	0.62	1961
114	42611	Sta. Catalina, Minalin	100,60	101.5	63.1	+ 1.8		Flowing 0.63		1961
115	43677	Pulong Palasan, Candaba	112	122.6	87.8	-10.7	-14.0	0.63	0.19	1967
116	43666	Pasing, Candaba	112	48.8	45.7	- 3.0	- 4.0	0.63	0.63	1966
117	436711	Bo. Lanang, Candaba	100	57.9	57.6	- 3.7	- 4.9	0.63	0.53	1958
118	43632	Pasing, Candaba	100	39.3	31.1	- 4.9	- 6.1	0.63	0.53	1963
119	17188	Gulap, Candaba	100	81.7	80.8	- 2.4	- 3.0	0.76	1.27	1957
120	6640	Mandili, Candaba	100	7.6	6.7	- 1.5	- 3.7	0.63	0.29	1954
121	5998	Poblacion, Candaba	150	50.3	30.2	- 3.0	- 5.5	0.95	0.38	1954
122	77187	Paralaya, Candaba	100	46.3	46.0	- 2.4	- 3.0	0.76	1.27	1957
123	426051	Mangga, Candaba	100	42.7	36.0	- 4.9	- 5.5	0.32	0.53	1960
124	426132	Mandasig, Candaba	100	42.7	42.7	- 6.1	- 9.1	0.32	0.11	1961
125	5948	Paralaya, Market Site, Candaba		50.3		- 4.6	- 7.6	0.76	0.25	1970
126	43631	San Juan, San Simon	75	50.6	50.6	- 3.0	- 6.1	0.76	0.25	1963

*Sta. Rita

ANNEX TABLE VII-3-1 (Continued)

CDM Well Number	BPW Well Number	Location	Nominal Diameter (mm)	Depth in Ground Surface in Meters: Total	Cased	Static Water Level	Pumping Water Level	Test Yield (lps)	Specific Capacity (lps/m)	Year Completed
46	7978	San Jose, Florida Blanca	150	13.7		- 2.4	- 4.5	0.63	0.3	1955
47	537204	Bo. Palmayo (School Site) Florida Blanca	112	57.9		-15.9	-17.7	0.94	0.52	1972
48	426271	Basa Air Base, Florida Blanca	200,150	126.5		- 6.4	-18.3	12.6	1.06	1962
49	19283	Sta. Monica, F. Blanca	100	29.6		- 1.8	- 9.8	0.38	0.05	1958
50	19281	Valdez, Florida Blanca	100	34.1		- 3.4	- 4.3	0.63	0.7	1958
51	19282	Bo. San Nicolas, (School Site) F. Blanca	100	34.1		- 5.2	- 5.5	0.54	1.8	1958
52	19277	Sitio Apalit Pabanlag, Florida Blanca	100	45.7		-17.1	-17.7	0.32	0.53	1958
53	19278	San Nicolas, Florida Blanca	100	29.6		- 3.7	- 5.5	1.26	0.7	1958
54	19275	Cabancalan, F. Blanca	100	34.1		- 0.3	- 0.6	0.76	2.53	1958
55	19276	Fortuna, Florida Blanca	100	29.6		- 1.8	- 2.1	0.94	3.13	1958
56	19274	Valdez, Florida Blanca	100	29.6		- 4	- 6.1	0.94	0.45	1958
57	18011	San Jose, Florida Blanca	100	27.4		- 3.7	- 6.1	0.74	0.32	1958
58	18010	Soled, Florida Blanca	100	34.1		- 1.2	- 2.4	1.26	1.05	1958
59	18012	Paguirauan, F. Blanca	100	29.6		- 2.4	- 3.0	0.38	0.63	1958
60	8667	Calangain, Lubao	150	32.8		+ 0.6		0.32 Flowing		1955
61	8259	Del Carmen, Lubao	150	26.2		- 1.2	- 4.6	0.63	0.18	1955
62	426153	Bo. Remedios, Lubao	112	97.6		+ 0.6		1.57 Flowing		1962
63	426021	Sta. Teresa, Lubao	100	69.5		+ 0.3	- 0.3	0.57	0.95	1960
64	426014	School Site, San Vicente Lubao	100	53.4		- 0.4	- 3	0.94	0.36	1960
65	426251	Bo. Sta. Teresa (School Site), Lubao	100	44.2		- 1.2	- 2.7	0.63	0.42	1962
66	8669	Sta. Cruz, Lubao	150	26.2		+ 0.9		1.89 Flowing		1956
67	5640	Arellano St., Lubao	100, 50	57.9		+ 0.3		0.32 Flowing		1953

ANNEX TABLE VII-B-1 (Continued)

CDM Well Number	BPW Well Number	Location	Nominal Diameter (mm)	Depth from Ground Surface in Meters: Total	Cased	Static Water Level	Pumping Water Level	Test Yield (lps)	Specific Capacity (lps/m)	Year Completed
127	2651	San Pedro, San Simon		42.7		- 3.0	- 3.0	0.32		1969
128	79755	San Isidro, San Simon		42.7		- 3.0	- 4.0	0.63	0.63	1968
129	43611	San Juan, San Simon		42.7		- 3.0	- 4.0	0.76	0.76	1968
130	6637	San Pedro, San Simon	150 100	43.6	10.1 32.9	- 1.4	- 2.9	1.26	0.84	1954
131	43692	Sta. Cruz, San Simon	112	48.8	48.8	- 3.0	- 4.0	0.76	0.76	1969
132	18067	San Pablo, San Simon		48.8		- 3.0	- 4.0	0.63	0.63	1970
133	43634	Dela Paz, San Simon	112	54.0	11.6	- 2.1	- 4.6	1.58	0.63	1963
134	436711	San Nicolas, San Simon	112	48.8	43.6	- 2.1	- 2.1	0.32		1967
135	5651	San Pedro, San Simon	100	48.8	46.3	- 2.1	- 3.4	0.95	0.73	1953
136	14591	Sta. Cruz, San Simon	112	35.1	31.7	- 3.4	- 4.3	0.95	1.05	1957
137	426124	San Juan I, San Luis	100	39.6		- 3.0	- 7.6	0.63	0.14	1967
138	16821	Sto. Rosario, San Luis	100	35.1	33.5	- 1.5	- 3.0			1956
139	426023	San Sebastian, San Luis	100	44.2	42.4	- 2.1	- 3.0	0.32	0.36	1960
140	426022	San Nicolas, San Luis	100	44.2	36.0	- 2.4	- 2.9	0.50	1.00	1960
141	426133	Sta. Cruz, San Luis	150	38.1	38.1	- 3.0	- 5.5	0.63	0.25	1961
142	426125	San Juan, San Luis	112	37.2	37.2	- 3.0	- 6.1	0.63	0.20	1961
143	436622	Sta. Rita, San Luis		39.6		- 3.7	- 6.7	0.63	0.21	1969
144	18060	Sta. Rita, San Luis	100	42.7	42.7	- 3.0	- 6.1	0.76	0.25	1969
145	426024	Sto. Tomas, San Luis	100	42.7	42.1	- 1.8	- 4.9	0.44	0.14	1960
146	426125	San Juan, San Luis	112	38.1	38.1	- 3.0	- 6.1	0.63	0.25	1961
147	426143	Sta. Monica, San Luis	112	42.7	32.9	- 1.5	- 2.1	0.76	1.27	1961
148	416144	San Juan, San Luis	112	38.1	25.9	- 0.9	- 1.8	0.76	0.84	1961
149	416143	Sta. Monica, San Luis	112	45.7	45.7	- 3.0		0.32		1966
150	5931	San Sebastian, San Luis	100	45.1	32.3	- 1.8	- 3.0	0.63	0.53	1954
151	426024	Sto. Tomas, San Luis	100	42.7	42.1	- 1.8	- 4.9	0.44		1960
152		P. Burgos St., San Luis	100	41.8	40.2	- 1.5	- 2.7	0.95	0.79	1952
153	14778	Cabalantian, Bacolor	112	68.6		- 0.6		0.63		1957
154	537202	Talba, Bacolor	100	100.6		- 3.0		0.32		1972
155	10859	Bacolor	250	157.9		+ 1.5		6.30		1957
156	14781	Palawe, Bacolor	62	88.4		+ 0.6		1.13		1962
157	14783	San Antonio, Bacolor	100	45.4		+ 1.5		0.63		1957
158	14780	Talba, Bacolor	100	91.5		0		0.76		1957
159	19273	Sta. Ines, Bacolor		42.7		- 1.5		0.76		1968
160	19271	Potrero, Bacolor				- 3.7		0.63		1964

ANNEX TABLE VII-B-1 (Continued)

CDM Well Number	BPW Well Number	Location	Nominal Diameter (mm)	Depth From Ground Surface in Meters: Total	Cased	Static Water Level	Pumping Water Level	Test Yield (lps)	Specific Capacity (lps/m)	Year Completed
161		Tinajero, Bacolor	75	79.3		– 0.9		0.63		1969
162	18009	Sta. Ines, Bacolor	62	79.3		– 3.0	– 4.3	0.63	0.48	1961
163	14779	Tinajero, Bacolor	112	77.4		+ 1.2		0.76		1957
164	8256	San Nicolas II, Betis, Guagua	150	28.0		– 1.5	– 2.7	0.63	0.53	1955
165	43691	San Antonio, Guagua	112	82.3		+ 0.3	– 0.9	1.26	1.05	1969
166	14782	Ebus, Guagua	100	13.1		– 1.8	– 2.4	0.63	1.05	1957
167	43687	Betis, Guagua	112	154.0		– 1.5				1968
168	17192	San Agustin, Guagua	100	43.3		– 0.8	– 1.5	0.76	1.09	1959
169	18020	San Miguel, Guagua	100	43.6		– 3.7	– 5.2	0.32	0.21	1969
170	426027	Sebitanan, Sexmoan	100	112.8	69.5	– 0.6	– 1.5	1.26	1.40	1961
171	20774	Batang I, Sexmoan	100	113.1	66.8	– 4.6		4.60	1.06	1958
172	14776	San Nicolas, Sexmoan	112	51.2	47.3	– 2.4		0.95		1957
173	6702	Malusac, Sexmoan		104.2		+ 1.8	0	1.89	1.05	1955
174	20775	Masumbuan, Sexmoan	100	100.6	51.8	– 5.8		3.15		1959
175	14777	Batang II, Sexmoan	112	69.5	69.0	+ 0.9		0.76		1957
176		Malusac, Sexmoan		122.0		+ 0.6	– 9.1	1.89	0.22	1973
177	5752	Sto. Tomas, Sexmoan	100	103.7	40.2	+ 1.5		0.95		1953
178	5753	Sto. Tomas, Sexmoan		26.8		– 0.6	–11.6	0.32	0.03	
179	14775	Sta. Lucia, Sexmoan	112	43.9	36.0	– 1.8		0.63		1957
180		Batang II, Sexmoan		106.7		+ 0.3	–11.6	2.84	0.24	1973
181	537301	San Nicolas, Sexmoan	112	64.0	39.6	– 1.5	– 3.7	0.32	0.15	1973
182	426033	Sapang Kawayan, Masantol	100	146.3	77.7	+ 3.7		1.26		1960
183	6108	Caingin, Masantol	150 100	60.4	7.6 29.0	– 0.5	– 2.0	0.63	0.42	1954
184	426273	Poblacion, Masantol	200 150	124.7	110.0 17.4	+ 0.6	– 3.4	12.6	3.15	1963
185	426026	Bebe Matua, Masantol	100	119.8	63.1	+ 0.6	0	0.44	0.73	1960
186	426035	Bagang, Masantol	100	158.5	58.5	+ 0.6	– 0.6	0.50	0.42	1961
187	17185	Paligue, Apalit	100	78.4	69.9	+ 0.3	0	0.76	2.53	1957
188	537308	Purok IV, Sucad, Apalit	112	54.9	30.5	– 3.0	– 4.6	0.32	0.20	1974
189	53741	PRCS–BPW, Sulipan, Apalit	150 100	157.3	30.0 91.5	– 3.0	–12.2	12.60	1.37	1974
190	537311	Purok II, Sucad, Apalit	112	48.2	44.2	– 5.5	– 7.0	0.95	0.63	1974

ANNEX TABLE VII-B-1 (Continued)

CDM Well Number	BPW Well Number	Location	Nominal Diameter (mm)	Depth From Ground Surface in Meters: Total	Cased	Static Water Level	Pumping Water Level	Test Yield (lps)	Specific Capacity (lps/m)	Year Completed
191	537302	Cansinata, Apalit	112	47.9	43.9	- 4.3	- 7.6	0.32	0.10	1973
192	8128	San Juan II, Apalit	150	86.9	73.5	+ 0.3		1.26		1955
193	537203	San Juan, Apalit	112	130.2	114.9	- 1.2	- 1.5	0.95	3.17	1972
194	5807	Sucad, Apalit	100	114.6	43.9	+ 1.8		1.07		1953
195	19255	Sulipan, Apalit		50.3		- .9				1970
196	8129	Alauli, San Vicente, Apalit	150	54.3	46.3	- 0.6	- 3.7	0.95	0.31	1955
197	8125	San Juan I, Apalit	150	51.8	42.6	- 0.6	- 9.1	0.63	0.07	1955
198	425921	Bulaon, San Fernando	100	17.7	17.7	- 3.0	- 3.7	0.44	0.63	1959
199	6287	Macabebe Elem. Sch. Macabebe	150	99.1	89.6	0	- 1.5	3.78	2.52	1954
200	426066	San Gabriel, Macabebe	100	129.6	122.9	+ 0.8		0.63		1960
201	17048	Bulaon, San Fernando	100	18.3		- 3.0	- 3.7	0.32	0.46	1958
202	426253	Pasbulbulu, Porac	100	48.8	44.8	-25.0	-26.2	0.63	0.53	1962
203	17040	Sitio Baidbid, Sepung-Bulaon Porac	150	23.5	21.3	-10.7	-12.2	0.95	0.63	1957
204	18059	Planas, Porac		36.6		-16.8	-18.3	0.76	0.51	1961
205	426017	Cangatba, Porac	100	19.8	14.7	- 0.6	- 3.0	0.63	0.26	1961
206	22091	Pulung Mababa, Porac	100	20.1	20.0	-14.6	-16.2	0.63	0.39	1959
207	13156	Mangcatian, Porac	112	18.6	16.2	- 9.4	-11.0	0.50	0.31	1956
208	13157	Manggatian, Porac	112	13.1	12.2	- 6.1	- 7.0	0.50	0.56	1956
209	13159	Calzadang Bayo, Porac	112	16.2	13.6	- 2.4	- 4.0	0.95	0.59	1956
210	13160	Jalung, Porac	112	25.9	23.8	- 9.8	-11.3	0.50	0.33	1956
211	13161	Mitla, Porac	112	21.6	21.6	- 9.4	-10.1	0.63	0.90	1956
212	42601	Manuale, Porac	100	45.4	45.1	-39.9	-40.5	0.44	0.73	1960
213	17183	Patad, Porac	100	28.0	19.5	-17.7	-21.3	0.44	0.12	1957
214	13158	Manibang, Porac	112	11.9	9.9	- 5.2	- 5.5	0.82	2.73	1956
215	13162	Sepung Bulaon, Porac	112	21.3	20.4	- 9.8	-10.1	0.63	2.10	1956
216	5559	Pio, Porac	112	24.1	15.2	-12.8		0.32		1952
217	5957	Planas, Porac	150 100	31.7	10.1 11.3	- 9.1	-10.7	0.44	1.10	1954
218	13155	Mangcatian, Porac	112	14.9	13.7	-10.7	-11.3			1956
219	14784	Pulong Santol, Porac	100	21.3	19.8	- 4.6	- 9.1	0.44	0.10	1957
220	10864	San Angelo Subd., Angeles		213.4		- 3.7	-25.9	15.75	0.71	1959
221	10863	Pandan, Angeles	150	128.0	76.2	- 0.9				1958
222	426032	Margot, Angeles	100	62.5	35.4	-27.4	-35.1	0.32	0.04	1960
223	426025	Pulong Cacutod, Angeles	100	13.7	12.2	- 3.7	- 4.9	0.38	0.48	1960

ANNEX TABLE VII-B-1 (Continued)

CDM Well Number	BPW Well Number	Location	Nominal Diameter (mm)	Depth From Ground Surface in Meters: Total	Cased	Static Water Level	Pumping Water Level	Test Yield (lps)	Specific Capacity (lps/m)	Year Completed
224	426111	Balibago, Angeles	100	62.5	60.4	- 2.7	- 4.6	0.95	0.50	1961
225	10857	Lourdes, Angeles	250 200	106.1	51.8 52.2	- 4.3		18.90		1956
226	5440	Sto. Rosario St., Angeles	200 150	128.0	67.7 58.8	- 2.4	- 5.8	7.56	2.22	1952
227	6553	Sapang Bato, Angeles	150 100	60.1	16.2 27.7	-26.8	-32.0	0.38	0.07	1954
228	426032A	Margot, Angeles	100	39.6	10.1	-29.9	-32.0	0.50	0.24	1962
229	20771	Baluga Village, Angeles	62 100	28.7	25.0	-18.9	-20.7	0.63	0.35	1962
230	43678	Balibago, Angeles	150	57.9	57.9	- 2.4	- 5.5	3.78	1.22	1967
231	20241	Clark Field, Angeles	200 150	106.1	21.5 72.9	-25.9	-30.5	8.82	1.92	1957
232	6286	Kuliat, Lourdes, Angeles	150 100	103.7	79.9	- 2.4	-25.9	7.56	0.32	1954
233	4901	Miranda St., Angeles	200 150	262.2	135.7 125.6	- 7.3	-12.2	4.73	0.96	1949
234	19265	Cacutod, Arayat	62	56.7	28.4	- 2.4	- 4.9	0.63	0.25	1961
235	53712	Bitas, Arayat	112	44.2	34.1	- 1.5	- 6.1	0.95	0.21	1971
236	426122	Cupang, Arayat	100	44.8	44.8	- 3.7	- 6.1	0.63	0.26	1961
237	426123	Matamo, Arayat	100	34.4	34.4	- 3.0	- 4.6	0.63	0.39	1961
238	426152	Arenas, Arayat	100	40.2	36.6	0	- 0.6	0.63	1.05	1961
239	9020	Batasan, Arayat	112	25.6	18.3	- 3.0	- 4.6	2.21	1.38	1955
240	9019	Batasan, Arayat	112	42.7	26.2	- 4.6	- 5.2	1.89	3.15	1955
241	426121	Cupang, Arayat	100	50.3	46.3	- 4.6	-12.2	0.63	0.08	1961
242	9530	Lumbac, Pulilan, Bulacan		29.0		- 4.9	- 7.9	0.63	0.21	1956
243	9528	Inaon, Pulilan, Bulacan		25.9		0	- 4.6	0.63	0.14	1956
244	7020	Tilapayong, Baliwag, Bulacan	150 100	24.7	17.5	- 0.9	- 2.1	1.58	1.32	1954
245	11667	Malamig, Sto. Cristo, Baliwag, Bulacan	112	12.2	11.0	- 1.14	- 1.21	0.95	13.57	1966

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ANNEX TABLE VII-B-1 (Continued)

CDM Well Number	BPW Well Number	Location	Nominal Diameter (mm)	Total	Cased	Static Water Level	Pumping Water Level	Test Yield (lps)	Specific Capacity (lps/m)	Year Completed
246		Pepsi Cola Plant, San Fernando		365.8		- 7.3 -15.5 (1977)				1966
247		Pilar Village, San Fernando		118.9			-12.0	9.45		1973
248		Pilar Village, San Fernando				-10.4				1976
249		Cosmos Plant, San Fernando				-12.2	-16.6	22.05	5.01	1973
250		Cosmos Plant, San Fernando				-12.6				1975
251		Central Luzon Gen. Hospital						6.30		1964
252		PASUDECO, San Fernando		304.9		- 6.2				1976
253		PASUDECO, San Fernando		304.9		- 5.2		37.8		1976
254		SFELAPCO, San Fernando		137.2		-12.2				1975
255		Coca-Cola Plant, San Fernando				- 7.6 - 7.3 (1975)		6.93		1957
256		Coca-Cola Plant, San Fernando				- 7.6 - 7.3 (1975)		6.93		1965

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ANNEX TABLE VII-B-2

CONSTANT RATE PUMPING TEST - SAN FERNANDO CDM NO. 3

Data:	Start Pumping	12 February 1977, 12:15 pm
	Start Recovery	14 February 1977, 12:15 pm
	Pumping Rate	44.1 lps
	Original SWL of Pumping Well	11.0 m
	Original SWL of Observation Well	10.63 m

DRAWDOWN

	Pumping Well Data		Observation Well Data	
Pumping Time (min)	Water Level (m)	Drawdown (m)	Water Level (m)	Drawdown (m)
0	11.0	0	10.63	0
0.5	19.90	8.90	10.65	0.02
1	20.65	9.65	10.61	0.02 (+)
1.5	20.92	9.92	10.63	0
2	21.20	10.20	10.64	0.01
2.5	21.51	10.51	10.64	0.01
3	21.87	10.87	10.64	0.01
3.5	22.50	11.50	10.65	0.02
4	23.67	12.67	10.66	0.03
4.5	23.50	12.50	10.67	0.04
5	24.12	13.12	10.68	0.05
6	24.35	13.35	10.70	0.07
7	24.56	13.56	10.73	0.10
8	25.00	14.00	10.76	0.13
9	25.27	14.27	10.78	0.15
10	25.43	14.43	10.80	0.17
12	25.80	14.80	10.86	0.23
15	26.25	15.25	10.92	0.29
18	26.68	15.68	11.00	0.37
20	26.90	15.90	11.05	0.42
25	27.40	16.40	11.16	0.53
30	27.81	16.82	11.26	0.63
35	28.17	17.17	11.36	0.73
40	28.34	17.34	11.45	0.82
45	28.38	17.38	11.52	0.89
50	28.65	17.65	11.61	0.98
55	28.88	17.88	11.70	1.07
60	29.00	18.00	11.84	1.21
70	29.48	18.48	11.92	1.29
80	29.77	18.77	12.05	1.42
90	29.90	18.90	12.17	1.54
100	30.05	19.05	12.26	1.63

ANNEX TABLE VII-B-2 (Continued)

Pumping Time (min)	Pumping Well Data: Water Level (m)	Pumping Well Data: Drawdown (m)	Observation Well Data: Water Level (m)	Observation Well Data: Drawdown (m)
110	30.16	19.16	12.36	1.73
120	30.29	19.29	12.46	1.83
150	30.57	19.57	12.69	2.06
180	30.80	19.80	12.89	2.26
210	31.27	20.27	13.08	2.45
240	31.44	20.44	13.25	2.62
270	31.61	20.61	13.40	2.77
300	31.75	20.75	13.53	2.90
330	31.87	20.87	13.66	3.03
360	31.95	20.95	13.76	3.13
420	32.14	21.14	14.00	3.37
480	32.15	21.15	14.15	3.52
540	32.69	21.69	14.30	3.67
600	32.96	21.96	14.45	3.82
660	33.12	22.12	14.55	3.92
720	33.20	22.20	14.70	4.07
780	33.26	22.26	14.80	4.17
840	33.30	22.30	14.90	4.27
900	33.41	22.41	14.95	4.32
960	33.52	22.52	15.04	4.41
1020	33.61	22.61	15.13	4.50
1080	33.72	22.72	15.19	4.56
1140	33.75	22.75	15.21	4.58
1200	33.63	22.63	15.31	4.68
1260	33.68	22.68	15.38	4.75
1320	33.74	22.74	15.43	4.80
1380	33.76	22.76	15.48	4.85
1440	33.72	22.72	15.52	4.89
1500	33.78	22.78	15.56	4.93
1560	33.82	22.82	1560	4.97
1620	33.92	22.92	15.63	5.00
1680	33.94	22.94	15.68	5.05
1740	34.12	23.12	15.73	5.10
1800	34.21	23.21	15.80	5.17
1860	34.37	23.37	15.83	5.20
1920	34.39	23.39	15.85	5.22
1980	34.43	23.43	15.89	5.26
2040	34.48	23.48	15.94	5.31
2100	34.50	23.50	15.98	5.35
2160	34.54	23.54	16.00	5.37
2220	34.57	23.57	16.06	5.43

ANNEX TABLE VII-B-2 (Continued)

Pumping Time (min)	Pumping Well Data		Observation Well Data	
	Water Level (m)	Drawdown (m)	Water Level (m)	Drawdown (m)
2280	34.59	23.59	16.11	5.48
2340	34.60	23.60	16.14	5.51
2400	34.67	23.67	16.17	5.55
2460	34.72	23.72	16.20	5.57
2520	34.82	23.82	16.22	5.59
2580	34.89	23.89	16.24	5.61
2640	35.08	24.08	16.28	5.65
2700	34.95	23.95	16.32	5.69
2760	34.95	23.95	16.35	5.72
2820	34.94	23.94	16.37	5.74
2880	35.00	24.00	16.38	5.75

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ANNEX TABLE VII-B-2 (Continued)

RECOVERY

Time Since Pumping Started (min)	Time Since Recovery Started (min)	Pumping Well Recovery (m)	Observation Well Recovery (m)
2880	0	0	0
2881	1	11.31	0.04
2882	2	12.17	0.05
2883	3	12.78	0.06
2884	4	13.28	0.08
2885	5	13.66	0.10
2886	6	14.02	0.12
2887	7	14.32	0.15
2888	8	14.56	0.17
2889	9	14.82	0.20
2890	10	15.03	0.22
2892	12	15.41	0.26
2895	15	15.86	0.34
2900	20	16.46	0.45
2905	25	16.84	0.57
2910	30	17.20	0.68
2920	40	17.74	0.85
2930	50	18.11	1.02
2940	60	18.42	1.16
2950	70	18.67	1.31
2960	80	18.87	1.41
2980	100	19.21	1.62
3000	120	19.48	1.81
3030	150	19.81	2.03
3060	180	20.06	2.21
3120	240	20.45	2.52
3180	300	20.73	2.77
3240	360	20.96	2.96
3360	480	21.29	3.23
3420	540	21.45	3.35
3480	600	21.59	3.54
3600	720	21.80	3.69
3840	960	22.10	4.02
3960	1080	22.22	4.12
4080	1200	22.32	4.19
4260	1380	22.45	4.34
4320	1440	22.50	4.40

ANNEX TABLE VII-B-3

CONSTANT RATE PUMPING TEST - CDM WELL NO. 4

Data:	Start Pumping	21 May 1977, 9:00 am
	Pumping Rate	9.5 lps
	Original Static Water Level	8.63 m

DRAWDOWN TEST

Pumping Time (min)	Water Level (m)	Drawdown (m)	Pumping Time (m)	Water Level (m)	Drawdown (m)
0	8.63	0	22	15.98	7.35
1	13.87	5.24	24	16.13	7.50
2	14.09	5.46	26	16.10	7.47
3	14.39	5.76	28	16.13	7.50
4	14.66	6.03	30	16.16	7.53
5	14.88	6.25	32	16.10	7.47
6	15.03	6.40	34	15.98	7.35
7	15.12	6.49	36	16.10	7.47
8	15.12	6.49	38	16.16	7.53
9	15.21	6.58	40	16.22	7.59
10	15.30	6.67	45	16.25	7.62
11	15.37	6.74	50	16.31	7.68
12	15.49	6.86	55	16.34	7.71
13	15.55	6.92	60	16.43	7.80
14	15.58	6.95	70	16.62	7.99
15	15.61	6.98	80	16.37	7.74
16	15.64	7.01	90	16.37	7.74
17	15.79	7.16	120	16.10	7.47
18	15.79	7.16	150	16.16	7.53
19	15.85	7.22			
20	15.76	7.13			

ANNEX TABLE VII-B-4

CONSTANT RATE PUMPING TEST - CDM WELL NO. 5

Data:	Start Pumping	20 May 1977, 1:00 pm
	Pumping Rate	6.3 lps
	Original Static Water Level	9.22 m

DRAWDOWN TEST

Pumping Time (min)	Water Level (m)	Drawdown (m)	Pumping Time (min)	Water Level (m)	Drawdown (m)
0	9.22	0	22	28.32	19.10
1	20.38	11.16	24	28.41	19.19
2	22.57	13.35	26	28.45	19.23
3	24.11	14.89	28	28.53	19.31
4	25.10	15.88	30	28.58	19.36
5	25.53	16.31	31	28.66	19.44
6	25.84	16.62	34	18.71	19.49
7	26.12	16.90	36	28.75	19.53
8	26.42	17.20	38	28.77	19.55
9	26.80	17.58	40	28.84	19.62
10	27.08	17.86	45	29.17	19.95
11	27.21	17.99	50	29.26	20.04
12	27.31	18.09	55	29.32	20.10
13	27.59	18.37	60	29.41	20.19
14	27.67	18.45	70	29.47	20.25
15	27.74	18.52	80	29.50	20.28
16	27.80	18.58	90	29.62	20.40
17	27.84	18.62	120	29.76	20.54
18	27.95	18.73	150	29.93	20.71
19	28.05	18.83			
20	28.20	18.98			

ANNEX TABLE VII-B-5

CONSTANT RATE PUMPING TEST - CDM WELL NO. 6

Data: Start Pumping 24 May 1977, 9:15 am
Pumping Rate 18.9 lps
Original Static
Water Level 8.33 m

DRAWDOWN TEST

Pumping Time (min)	Water Level (m)	Drawdown (m)
0	8.33	0
1	15.50	7.17
2	16.93	8.60
3	17.91	9.58
4	18.62	10.29
5	19.12	10.97
6	19.55	11.22
7	19.89	11.56
8	20.19	11.86
9	20.36	12.03
10	20.55	12.22
11	20.63	12.30
12	20.73	12.40
13	20.83	12.50
14	20.88	12.55
15	21.04	12.71
16	21.14	12.81
17	21.20	12.87
18	21.29	12.96
19	21.37	13.04
20	21.39	13.06
22	21.55	13.22
24	21.59	13.26
26	21.67	13.34
28	21.73	13.40
30	21.80	13.47
32	21.90	13.57
34	21.96	13.63
36	22.03	13.70
38	22.07	13.74
40	22.09	12.76
45	22.23	13.90
50	22.32	13.99
55	22.40	14.07
60	22.41	14.08
70	22.61	14.28
80	22.70	14.37
90	22.77	14.43
120	22.92	14.59
150	22.97	14.64

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ANNEX TABLE VII-B-6

CONSTANT RATE PUMPING TEST - CDM WELL NO. 7

Data: Start Pumping 25 May 1977, 7:00 pm
Pumping Rate 25.2 lps
Original Static
Water level 10.7 m

DRAWDOWN TEST

Pumping Time (min)	Water Level (m)	Drawdown (m)	Pumping Time (min)	Water Level (m)	Drawdown (m)
0	10.71	0	22	16.08	5.37
1	14.66	3.95	24	16.15	5.44
2	14.86	4.15	26	16.17	5.46
3	14.84	4.13	28	16.31	5.60
4	15.02	4.31	30	16.35	5.64
5	15.19	4.48	32	16.39	5.68
6	15.24	4.53	34	16.46	5.75
7	15.37	4.66	36	16.54	5.83
8	15.55	4.84	38	16.54	5.83
9	15.60	4.89	40	16.55	5.84
10	15.55	4.84	45	16.67	5.96
11	15.69	4.98	50	16.79	6.08
12	15.62	4.91	55	16.91	6.20
13	15.68	4.97	60	17.01	6.30
14	15.73	5.02	70	17.10	6.39
15	15.80	5.09	80	17.16	6.45
16	15.80	5.09	90	17.29	6.58
17	15.84	5.13	120	17.55	6.84
18	15.91	5.20	150	17.78	7.07
19	15.92	5.21			
20	15.93	5.22			

ANNEX TABLE VII-B-7

CONSTANT RATE PUMPING TEST - CDM WELL NO. 8

Data:		
	Start Pumping	20 May 1977, 9:00 am
	Pumping Rate	6.3 lps
	Original Static Water Level	9.15 m

DRAWDOWN TEST

Pumping Time (min)	Water Level (m)	Drawdown (m)	Pumping Time (m)	Water Level (m)	Drawdown (m)
0	9.15	0	22	22.03	12.88
1	16.39	7.24	24	22.16	13.01
2	18.06	8.91	26	22.25	13.10
3	18.75	9.60	28	22.36	13.21
4	19.28	10.13	30	22.46	13.31
5	19.61	10.46	32	22.57	13.42
6	20.02	10.87	34	22.68	13.53
7	20.20	11.05	36	22.77	13.62
8	20.35	11.20	38	22.84	13.69
9	20.55	11.40	40	22.93	13.78
10	20.73	11.58	45	23.15	14.00
11	20.86	11.71	50	23.30	14.15
12	21.00	11.85	55	23.48	14.33
13	21.14	11.99	60	23.68	14.53
14	21.29	12.14	70	23.90	14.75
15	21.43	12.28	80	24.07	14.92
16	21.49	12.34	90	24.26	15.11
17	21.63	12.48	105	24.70	15.55
18	21.70	12.55	120	24.87	15.72
19	21.82	12.67			
20	21.86	12.71			

DESCRIPTIVE DATA

WELL NO. (CDM) 2
(OTHER)
LOCATION BARRIO STO. ROSARIO
STO. TOMAS
CITY
PROVINCE PAMPANGA
CONST. BY B.P.W.
DRILLER
STARTED
COMPLETED 1970
OWNER B. P.W.
STATUS
CASING DIAMETER 150 MM
CASING LENGTH 144.8 M

DRILLER'S TEST DATA:

DATE
STATIC WATER LEVEL GROUND LEVEL
PUMPING WATER LEVEL 1.5 M
TEST PUMP YIELD 50.4 LPS
SPECIFIC CAPACITY 33.6 LPS/M

REMARKS:

WATER QUALITY DATA:

GRAPHIC LOG

DEPTH (M)	DEPTH (FT)	CASING	STRATIFICATION
			GROUND SURFACE
			BROWN CLAY
6.7	22		
			BLUE SANDY CLAY WITH SHELL
33.5	110		
			BLUE STICKY CLAY
72.6	238		
			SANDY CLAY WITH GRAVEL
76.2	250		
			BLUE SANDY CLAY
138.1	453		
			SAND AND GRAVEL
144.8	475		

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

ANNEX FIGURE VII-B-1
WELL DATA SHEET
WELL CDM-2
SAN FERNANDO WATER DISTRICT

DESCRIPTIVE DATA	GRAPHIC LOG

WELL NO. (CDM) 3
(OTHER) CL- 35,46
LOCATION BARRIO DEL ROSARIO
CITY SAN FERNANDO
PROVINCE PAMPANGA
CONST. BY
DRILLER
STARTED
COMPLETED OCTOBER 19, 1976
OWNER N.I.A.
STATUS
CASING DIAMETER 350 MM AND 200 MM
CASING LENGTH 60 M AND 246 M

DRILLER'S TEST DATA

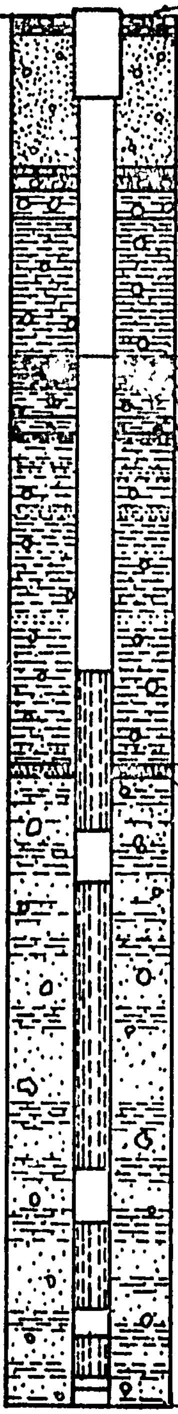
DATE MARCH 12, 1977
STATIC WATER LEVEL 11.0 M
PUMPING WATER LEVEL 35.0 M
TEST PUMP YIELD 44.1 LPS
SPECIFIC CAPACITY 1.84 LPS/M

REMARKS:

CL-46 WAS DRILLED DUE TO COLLAPSE IN CL- 35. EACH ARE ABOUT 80-100 M. AWAY IN BARRIO DEL ROSARIO.

WATER QUALITY DATA:

GRAPHIC LOG



DEPTH (M)	DEPTH (FT)	STRATIFICATION
		GROUND SURFACE
1	3.3	PUMICE GRAVEL WITH SAND
2	6.6	BROWN SILT
26	85.3	GRAY SAND LAYERED FINE-MED MED-COARSE, SOME PUMICE GRAVEL
27	88.6	SAND WITH GRANULES AND PEBBLES, SILTY
30	98.4	WHITE PUMICE GRAVEL WITH SAND
35	114.8	SILT AND CLAY WITH GRAVEL (LIGHT GRAY WHEN DRY)
60	196.8	TAN SILT AND CLAY WITH SOME SAND, SOME GRAVEL
61	200.1	BROWN SILT AND SAND
63	206.6	GRAY AND GREEN SILT AND FINE SAND WITH MANY SHELLS
65	213.2	GRAY CLAY, SOME SILT AND SHELL
71	232.9	GRAY SILT SOME SAND, SOME CLAY SOME SHELLS
75	246.0	GRAY CLAY, SOME SILT, SOME SHELLS
134	439.5	TAN AND GRAY SILT AND FINE SAND LAYERED, SOME GRAVEL SOME ASH LAYERS, SOME PUMICE
136	446.1	GRAY, FINE-MED SAND AND SILT
250	820	GRAY, FINE-MED-COARSE SAND WITH SOME PEBBLES AND SOME SILT LAYERED WITH SILTY FINE-MED-COURSE SAND SOME GRAVEL SHELL FRAG, SOME SILT LAYERS SOME ASH LAYERS.

ANNEX FIGURE VII-B-2
WELL DATA SHEET
WELL CDM - 3
SAN FERNANDO WATER DISTRICT

DESCRIPTIVE DATA	GRAPHIC LOG

WELL NO. (CDM) 4
(OTHER) 10862
LOCATION BARRIO SAN PEDRO
CITY SAN FERNANDO
PROVINCE PAMPANGA
CONST. BY B.P.W.
DRILLER
STARTED
COMPLETED 1958
OWNER SAN FERNANDO - WD
STATUS PRODUCTION WELL
CASING DIAMETER 200 MM
CASING LENGTH 218.6 M

DRILLER'S TEST DATA:

DATE 1958
STATIC WATER LEVEL ABOVE GROUND LEVEL
PUMPING WATER LEVEL GROUND LEVEL
TEST PUMP YIELD
SPECIFIC CAPACITY

REMARKS

1977 TEST DATA:

STATIC WATER LEVEL -8.5 M
PUMPING WATER LEVEL -17.9 M
TEST PUMP YIELD 11.9 LPS
SPECIFIC CAPACITY 1.26 LPS/M

WATER QUALITY DATA:

GRAPHIC LOG

GROUND SURFACE

DEPTH (M)	DEPTH (FT)	STRATIFICATION
1.5	5	BROWN STICKY CLAY
67.1	220	BLUE STICKY CLAY
73.2	240	BLUE SANDY CLAY
78.7	258	SAND
84.5	277	SAND AND GRAVEL
85.4	280	SAND
93.0	305	SANDSTONE
109.5	359	BLUE SANDY CLAY
111.3	365	SAND
124.1	407	BLUE STICKY CLAY
127.1	417	SAND
146.3	480	BLUE STICKY CLAY
158.5	520	BROWN SANDY CLAY
182.9	600	BLUE SANDY CLAY
184.5	605	SAND
218.6	717	SANDSTONE

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS **LWUA-CDM**

ANNEX FIGURE VII-B-3
WELL DATA SHEET
WELL CDM - 4
SAN FERNANDO WATER DISTRICT

DESCRIPTIVE DATA	GRAPHIC LOG

WELL NO. (CDM) 5
(OTHER) 6288
LOCATION CAPITOL SITE, STO. NIÑO

CITY SAN FERNANDO
PROVINCE PAMPANGA
CONST. BY B.P.W.
DRILLER
STARTED
COMPLETED
OWNER SAN FERNANDO - WD
STATUS PRODUCTION WELL
CASING DIAMETER 8 INCHES (200 MM)
CASING LENGTH 561 FEET (171.0 M)

DRILLER'S TEST DATA :

DATE
STATIC WATER LEVEL -1.5 M
FREE FLOWING
PUMPING WATER LEVEL -13.7 M
TEST PUMP YIELD 12.6 LPS
SPECIFIC CAPACITY 1.03 LPS/M

REMARKS :

1977 TEST DATA:
STATIC WATER LEVEL -9.1 M
PUMPING WATER LEVEL -32.9 M
TEST PUMP YIELD 7.4 LPS
SPECIFIC CAPACITY 0.31 LPS/M

WATER QUALITY DATA :

DEPTH (M)	DEPTH (FT)	STRATIFICATION
		GROUND SURFACE
6.1	20	YELLOW CLAY
20.1	66	BLUE CLAY
24.4	80	SANDY CLAY
30.5	100	BLACK CLAY
36.6	120	SANDY CLAY
49.4	162	BLUE STICKY CLAY
50.9	167	FINE SAND
63.1	207	BLACK CLAY
70.1	230	ADOBE CLAY
77.7	255	FINE SAND
88.4	290	SAND WITH GRAVEL
106.7	350	BLUE STICKY CLAY
114.0	374	ADOBE
118.9	390	SAND WITH GRAVEL
132.6	435	BLUE STICKY CLAY
138.7	455	ADOBE CLAY
141.8	465	BLUE STICKY CLAY
144.8	475	SANDSTONE
150.9	495	SANDY CLAY
164.6	440	BLUE STICKY CLAY
166.2	545	ADOBE
169.8	557	SANDSTONE
171.0	561	SAND WITH GRAVEL

ANNEX FIGURE VII-B-4
WELL DATA SHEET
WELL CDM - 5
SAN FERNANDO WATER DISTRICT

DESCRIPTIVE DATA	
WELL NO. (CDM)	6
(OTHER)	5769
LOCATION	WATERWORKS, DOLORES
CITY	SAN FERNANDO
PROVINCE	PAMPANGA
CONST. BY	B.P.W.
DRILLER	
STARTED	
COMPLETED	1953
OWNER	SAN FERNANDO-WD
STATUS	PRODUCTION WELL
CASING DIAMETER	200 MM
CASING LENGTH	220.4 M

DRILLER'S TEST DATA:

DATE	
STATIC WATER LEVEL	+2.1 M
PUMPING WATER LEVEL	
TEST PUMP YIELD	12.6 LPS
SPECIFIC CAPACITY	

REMARKS:

1977 TEST DATA:

STATIC WATER LEVEL	-8.2 M
PUMPING WATER LEVEL	-23.1 M
TEST PUMP YIELD	19.2 LPS
SPECIFIC CAPACITY	1.29 LPS/M

WATER QUALITY DATA:

GRAPHIC LOG

GROUND SURFACE

DEPTH (M)	DEPTH (FT)	STRATIFICATION
		SANDY CLAY
7.6	25	YELLOW STICKY CLAY
30.5	100	SAND
38.1	125	BLUE STICKY CLAY
59.5	195	BLUE STICKY CLAY
65.5	215	SAND
81.7	268	YELLOW STICKY CLAY
86.9	285	SAND
88.4	290	BLUE STICKY CLAY
122.0	400	ADOBE CLAY
128.0	420	ADOBE ROCK
135.7	445	SANDY ROCK
152.4	500	SAND WITH GRAVEL
157.9	518	SANDSTONE
188.7	619	SAND AND GRAVEL
199.4	654	SANDSTONE
220.4	723	

ANNEX FIGURE VII-B-5
WELL DATA SHEET
WELL CDM-6
SAN FERNANDO WATER DISTRICT

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS

LWUA-CDM

DESCRIPTIVE DATA	
WELL NO. (CDM)	14
(OTHER)	42-59-11
LOCATION	DOLORES
CITY	SAN FERNANDO
PROVINCE	PAMPANGA
CONST. BY	B.P.W.
DRILLER	
STARTED	
COMPLETED	1959
OWNER	B.P.W.
STATUS	
CASING DIAMETER	150 MM
CASING LENGTH	198.2 M

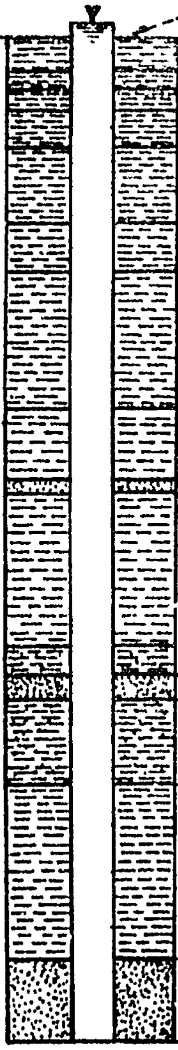
DRILLER'S TEST DATA:

DATE	
STATIC WATER LEVEL	GROUND LEVEL
PUMPING WATER LEVEL	-17.4 M
TEST PUMP YIELD	13.5 LPS
SPECIFIC CAPACITY	0.78 LPS/M

REMARKS:

WATER QUALITY DATA:

GRAPHIC LOG



DEPTH (M)	DEPTH (FT)	STRATIFICATION
		GROUND SURFACE
		BROWN CLAY
6.1	20	LIGHT BLUE CLAY
9.1	30	BLUE CLAY WITH SHELLS
13.7	45	BROWN CLAY
22.0	72	BROWN STICKY CLAY
36.6	120	BLUE STICKY CLAY
46.3	152	BROWN STICKY CLAY
73.2	240	BLUE STICKY CLAY
86.9	285	SAND
88.4	290	BLUE STICKY CLAY
118.9	390	BLUE SANDY CLAY
125.0	410	SAND
129.6	425	BLUE SANDY CLAY
146.3	480	BLUE STICKY CLAY
181.4	595	SAND
198.2	650	

ANNEX FIGURE VII-B-6
WELL DATA SHEET
WELL CDM-14
SAN FERNANDO WATER DISTRICT

DESCRIPTIVE DATA	
WELL NO. (CDM)	17
(OTHER)	436812
LOCATION	BARRIO ANAO MEXICO
CITY	
PROVINCE	PAMPANGA
CONST. BY	B.P.W.
DRILLER	
STARTED	
COMPLETED	1969
OWNER	B.P.W.
STATUS	
CASING DIAMETER	
CASING LENGTH	100.6 M

DRILLER'S TEST DATA:

DATE	
STATIC WATER LEVEL	-3.6 M
PUMPING WATER LEVEL	
TEST PUMP YIELD	
SPECIFIC CAPACITY	

REMARKS:

WATER QUALITY DATA:

GRAPHIC LOG

GROUND SURFACE

DEPTH (M)	DEPTH (FT)	STRATIFICATION
3.0	10	SANDY CLAY
10.7	35	ADOBE
13.7	45	BLUE CLAY
21.3	70	SAND
32.0	105	SANDSTONE
47.9	157	ADOBE
75.6	248	SANDSTONE
93.0	305	ADOBE
100.6	330	SANDSTONE

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS

LWUA-CDM

ANNEX FIGURE VII-B-7
WELL DATA SHEET
WELL CDM-17
SAN FERNANDO WATER DISTRICT

DESCRIPTIVE DATA

WELL NO. (CDM) 27
(OTHER)
LOCATION BARRIO SANTA MARIA
CITY MEXICO
PROVINCE PAMPANGA
CONST. BY B.P.W.
DRILLER
STARTED
COMPLETED 1968
OWNER B P W
STATUS
CASING DIAMETER 150 MM
CASING LENGTH

DRILLER'S TEST DATA

DATE
STATIC WATER LEVEL -0.9 M
PUMPING WATER LEVEL -2.1 M
TEST PUMP YIELD 31.5 LPS
SPECIFIC CAPACITY 26.25LPS/M

REMARKS:

WATER QUALITY DATA:

GRAPHIC LOG

DEPTH (M)	DEPTH (FT)	STRATIFICATION
		GROUND SURFACE
		BROWN CLAY
7.6	25	SAND
9.1	30	BLUE CLAY
13.7	40	BLUE CLAY WITH SHELL
22.0	72	YELLOW CLAY
39.0	128	SAND
44.2	145	ADOBE
47.0	154	SAND
50.9	167	ADOBE
55.5	182	SANDSTONE
59.1	194	ADOBE
68.6	225	SANDSTONE
87.5	287	ADOBE
90.9	298	SANDSTONE
98.2	322	

ANNEX FIGURE VII-B-8
WELL DATA SHEET
WELL CDM - 27
SAN FERNANDO WATER DISTRICT

DESCRIPTIVE DATA

WELL NO. (CDM) 69
(OTHER) 10858
LOCATION LUB..O
CITY
PROVINCE PAMPANGA
CONST BY B.P.W.
DRILLER
STARTED
COMPLETED 1957
OWNER B.P.W.
STATUS
CASING DIAMETER 250 MM
CASING LENGTH 2841 M

DRILLER'S TEST DATA:

DATE
STATIC WATER LEVEL -4 M
PUMPING WATER LEVEL
TEST PUMP YIELD
SPECIFIC CAPACITY

REMARKS:

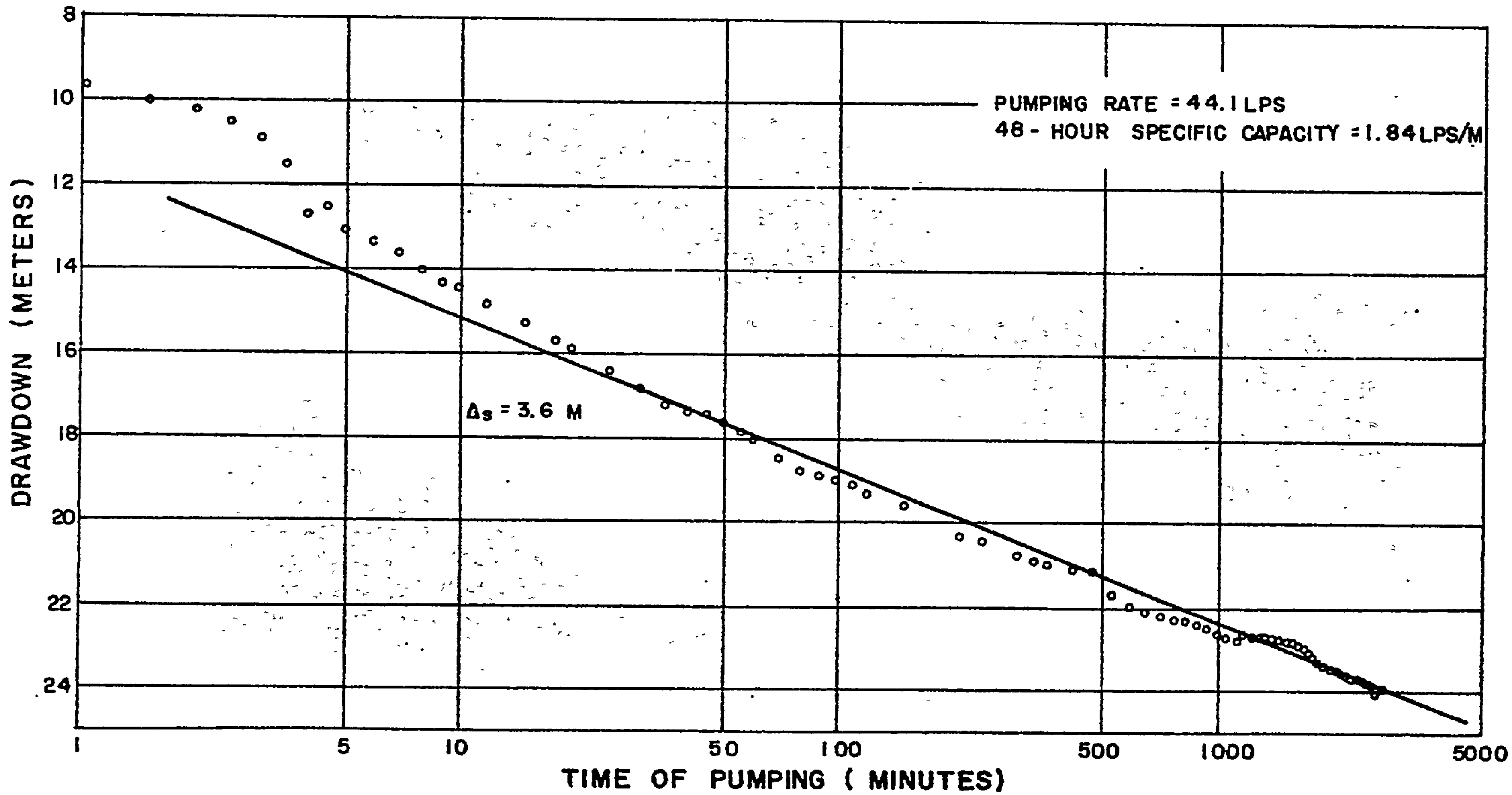
WATER QUALITY DATA:

GRAPHIC LOG

GROUND SURFACE

DEPTH (M)	DEPTH (FT)	STRATIFICATION
		BLUE CLAY
25.9	85	BLUE STICKY CLAY
72.3	237	SAND
72.9	239	BLUE STICKY CLAY
241.5	792	BROWN SANDY CLAY
250.0	820	SAND
253.7	832	SANDY CLAY
274.1	899	LIGHT BLUE CLAY AND SHELLS
284.1	932	

ANNEX FIGURE VII-B-9
WELL DATA SHEET
WELL CDM-69
SAN FERNANDO WATER DISTRICT



ANALYSIS BY JACOB'S MODIFICATION OF THE THEIS NON-EQUILIBRIUM FORMULA

$$T = \frac{0.183Q}{\Delta S}$$

Q = 3810 CUMD

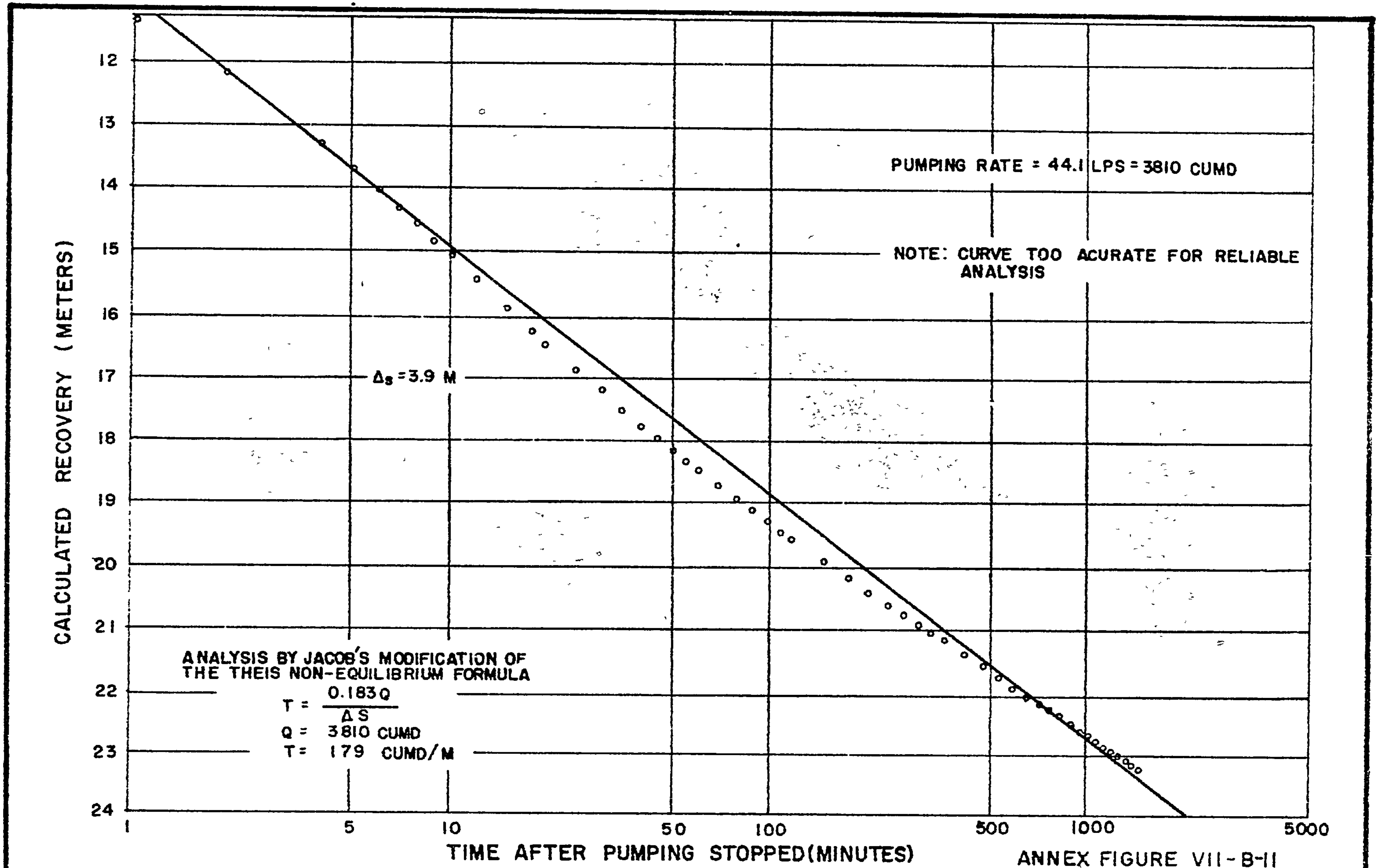
T = 194 CUMD/ M

ANNEX FIGURE VII - B-10

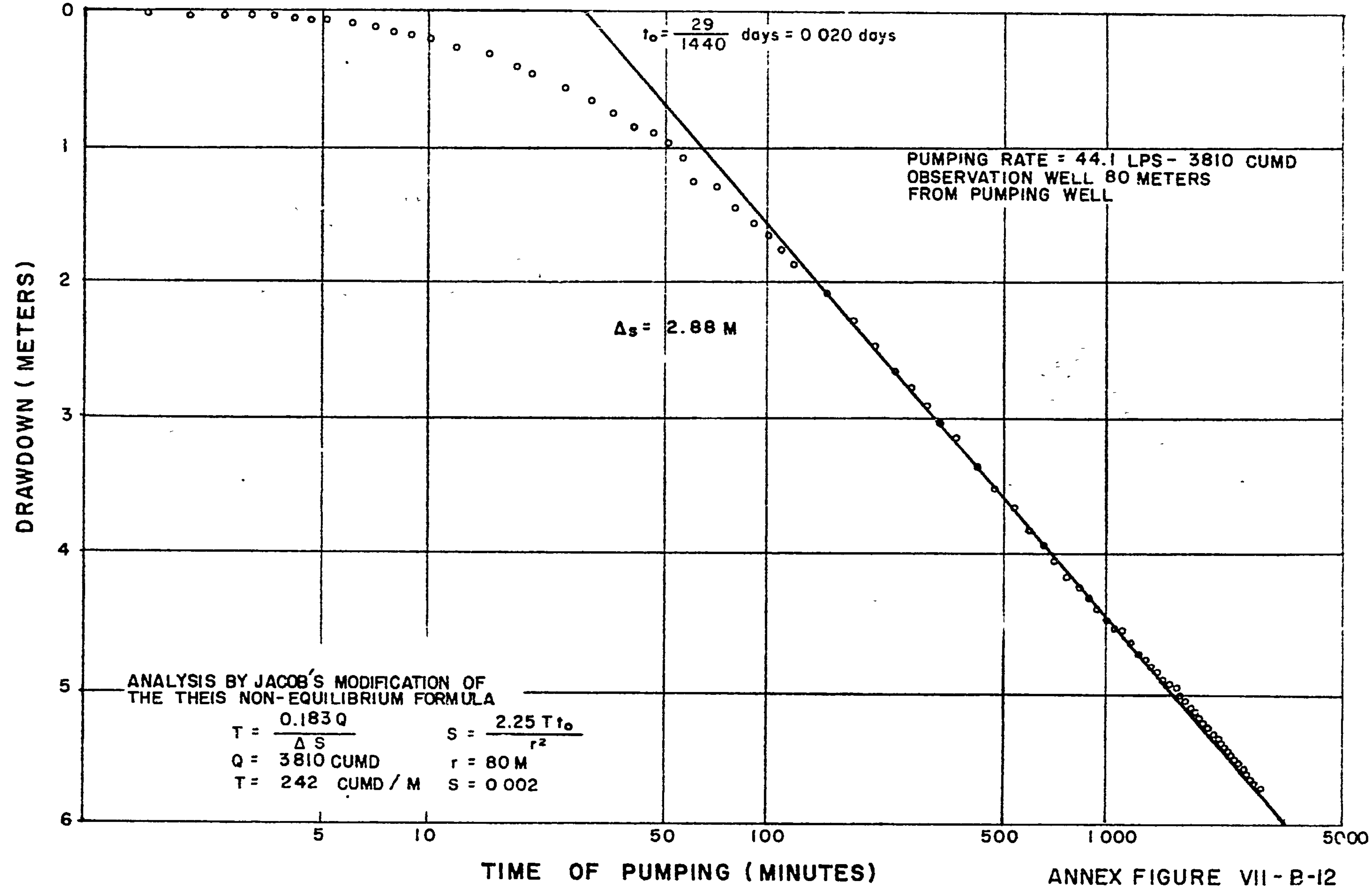
CONSTANT RATE PUMPING TEST

PUMPING WELL CDM-3

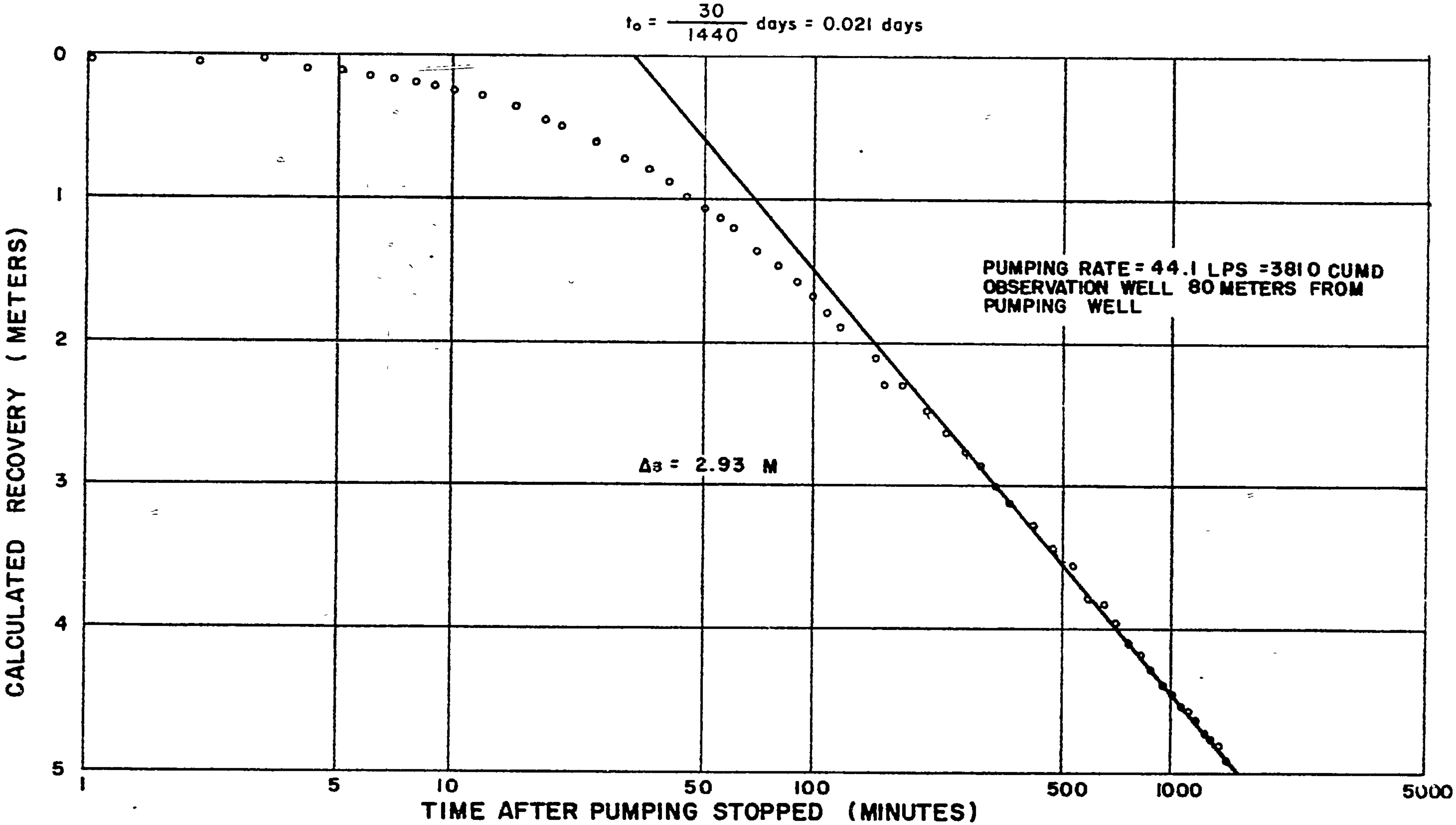
SAN FERNANDO WATER DISTRICT



ANNEX FIGURE VII-B-11
RECOVERY FROM CONSTANT RATE PUMPING TEST PUMPING WELL CDM-3
SAN FERNANDO WATER DISTRICT



ANNEX FIGURE VII - B-12
CONSTANT RATE PUMPING TEST
OBSERVATION WELL CDM-3
SAN FERNANDO WATER DISTRICT



ANALYSIS BY JACOB'S MODIFICATION OF THE THEIS NON-EQUILIBRIUM FORMULA

$T = \frac{0.183Q}{\Delta S}$

$S = \frac{2.25Tt_o}{r^2}$

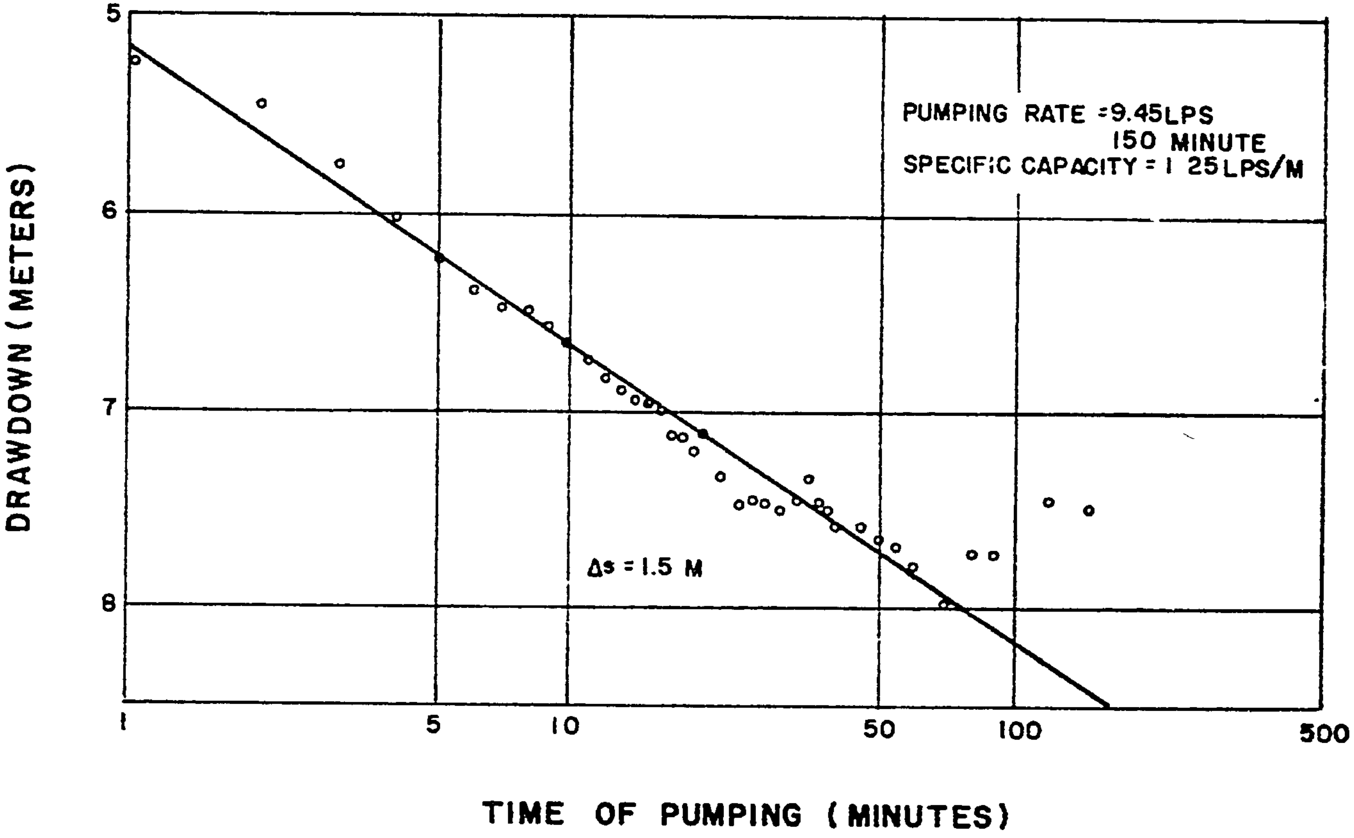
Q = 3810 CUMD

T = 238 CUMD/M

r = 80 M   S = 0.002

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS   LWUA-CDM

ANNEX FIGURE VII-B-13
RECOVERY FROM CONSTANT RATE PUMPING TEST-OBSERVATION WELL CDM-3
SAN FERNANDO WATER DISTRICT



ANALYSIS BY JACOB'S MODIFICATION OF THE THEIS NON-EQUILIBRIUM FORMULA

$$T = \frac{0.183\,Q}{\Delta S}$$

Q = 816 CUMD

T = 100 CUMD / M

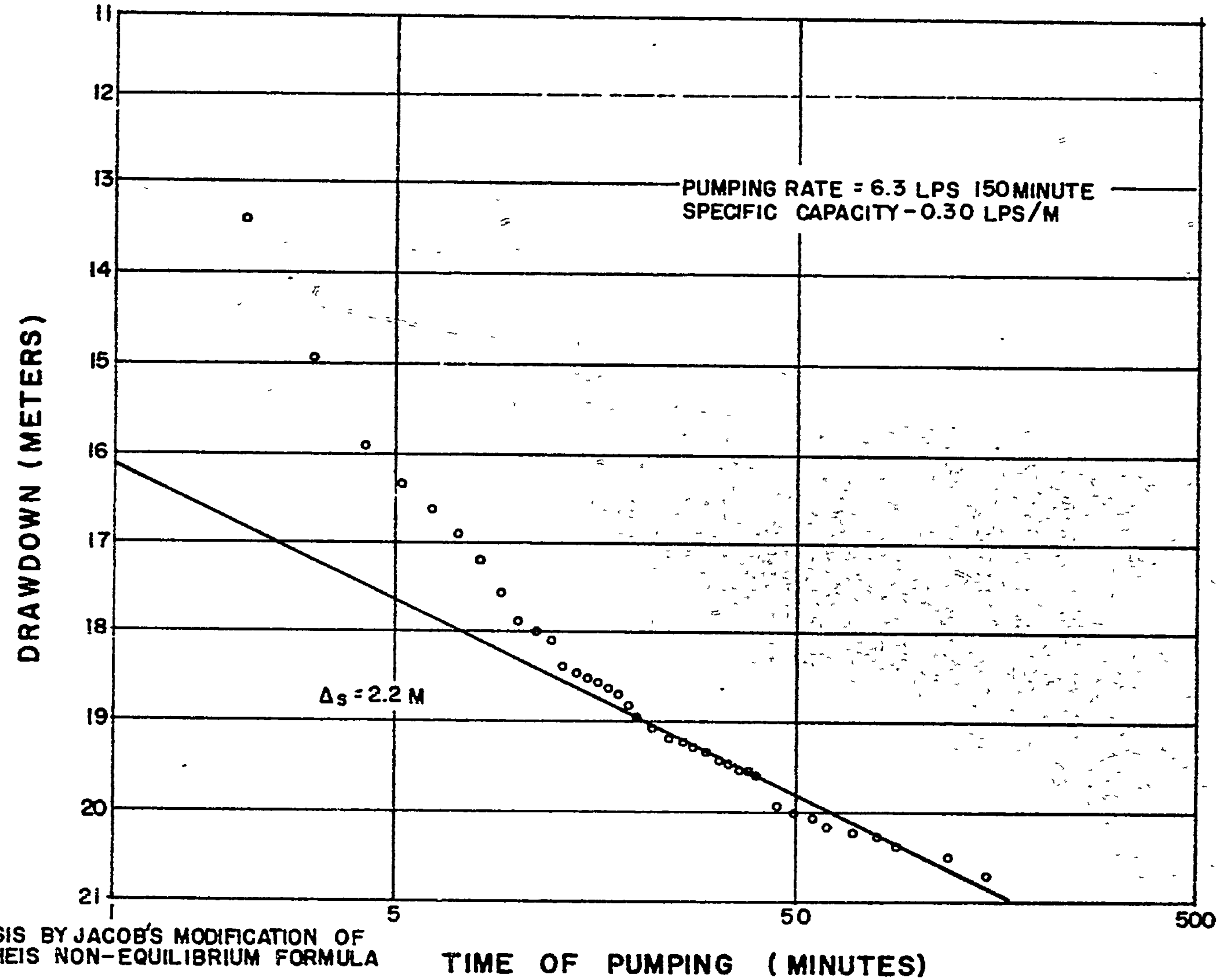
FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS **LWUA-CDM**

ANNEX FIGURE VII - B-14

CONSTANT RATE PUMPING TEST

PUMPING WELL CDM-4

SAN FERNANDO WATER DISTRICT



ANALYSIS BY JACOB'S MODIFICATION OF THE THEIS NON-EQUILIBRIUM FORMULA

$T = \frac{0.183Q}{\Delta S}$

Q = 544 CUMD

T = 45 CUMD/M

ANNEX FIGURE VII- B-15

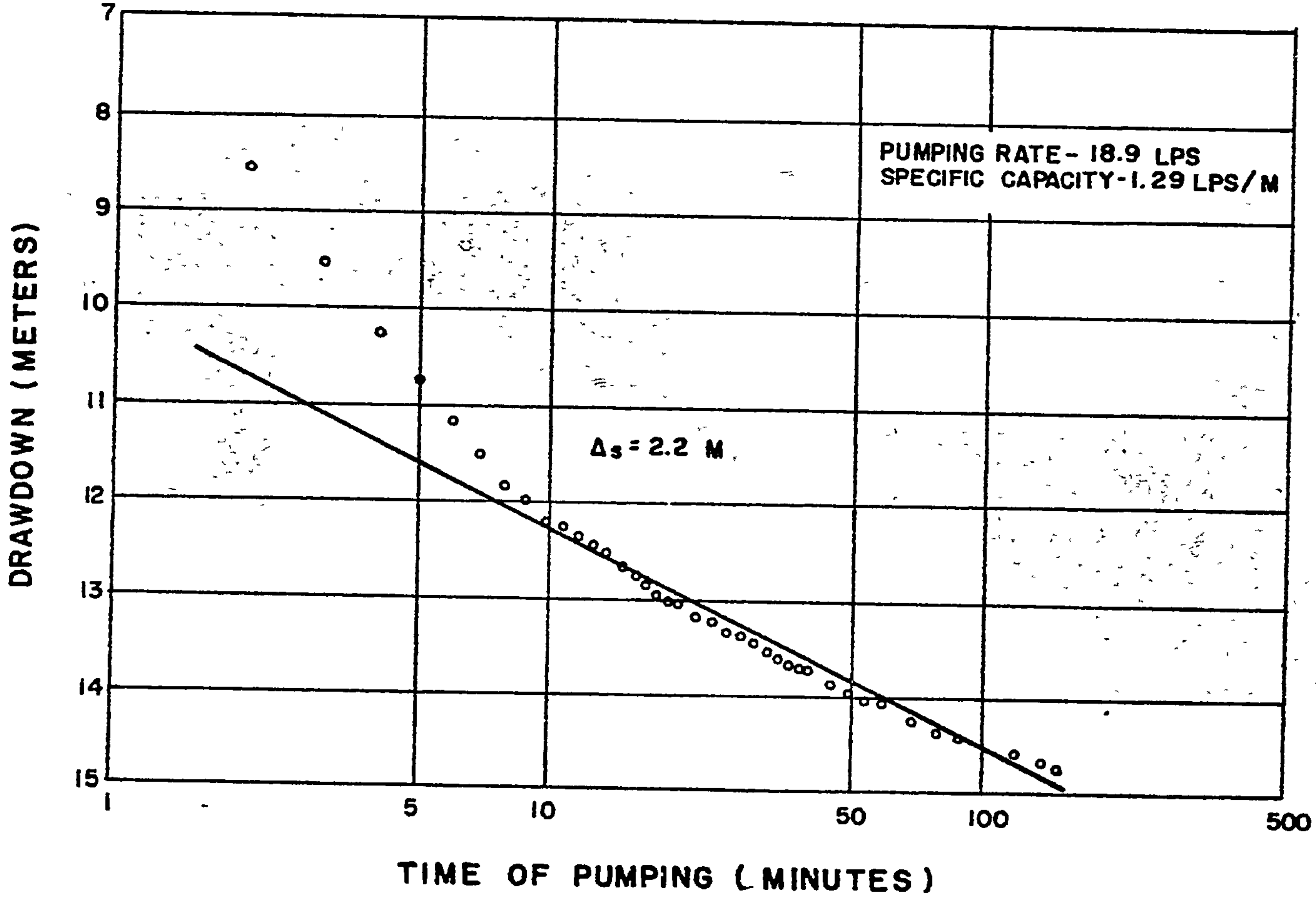
CONSTANT RATE PUMPING TEST

PUMPING WELL CDM-5

SAN FERNANDO WATER DISTRICT

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS

LWUA-CDM



ANALYSIS BY JACOB'S MODIFICATION OF THE THEIS NON-EQUILIBRIUM FORMULA

$$T = \frac{0.183Q}{\Delta S}$$

Q = 1632 CUMD

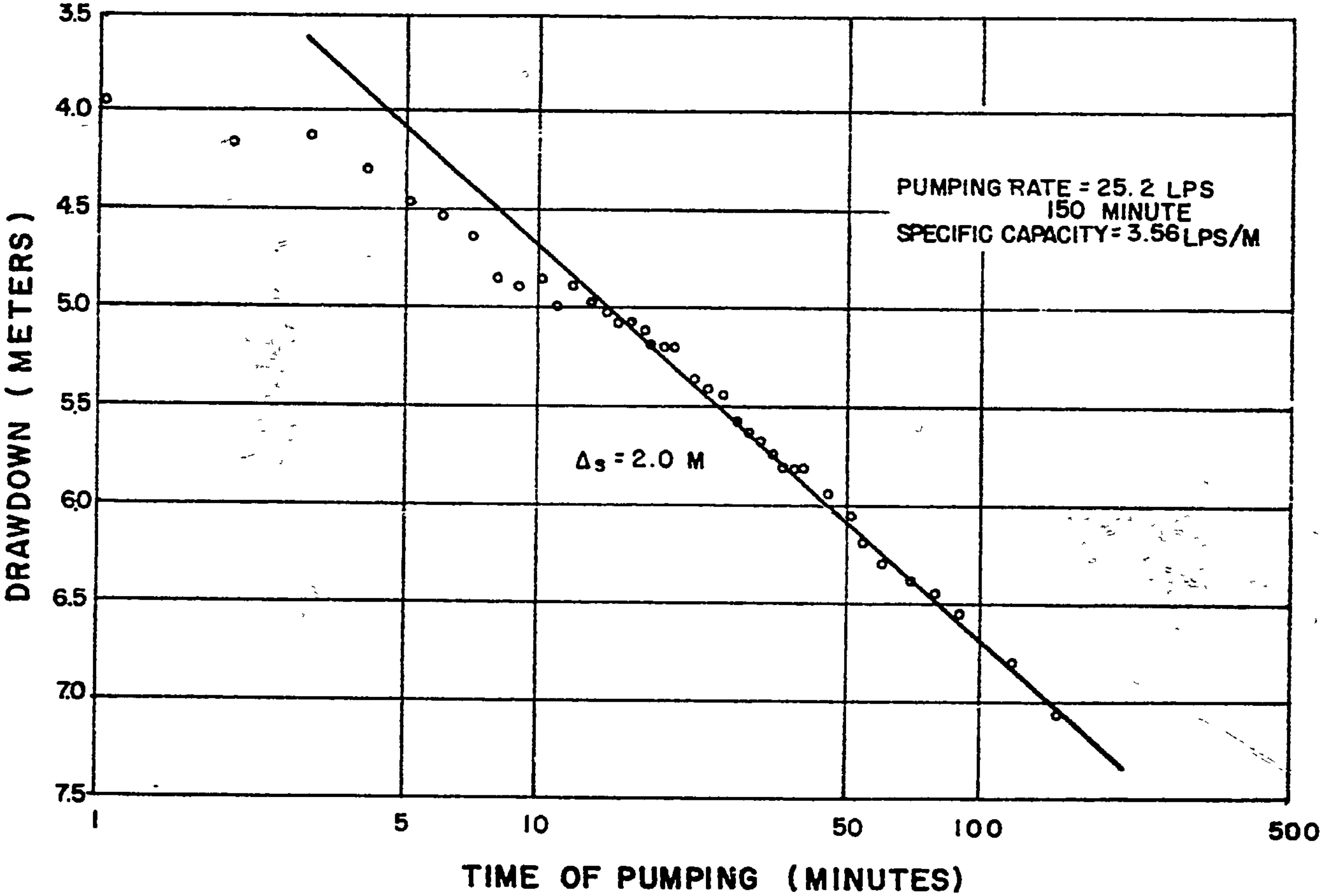
T = 136 CUMD/M

ANNEX FIGURE VII - B-16

CONSTANT RATE PUMPING TEST

PUMPING WELL CDM-6

SAN FERNANDO WATER DISTRICT

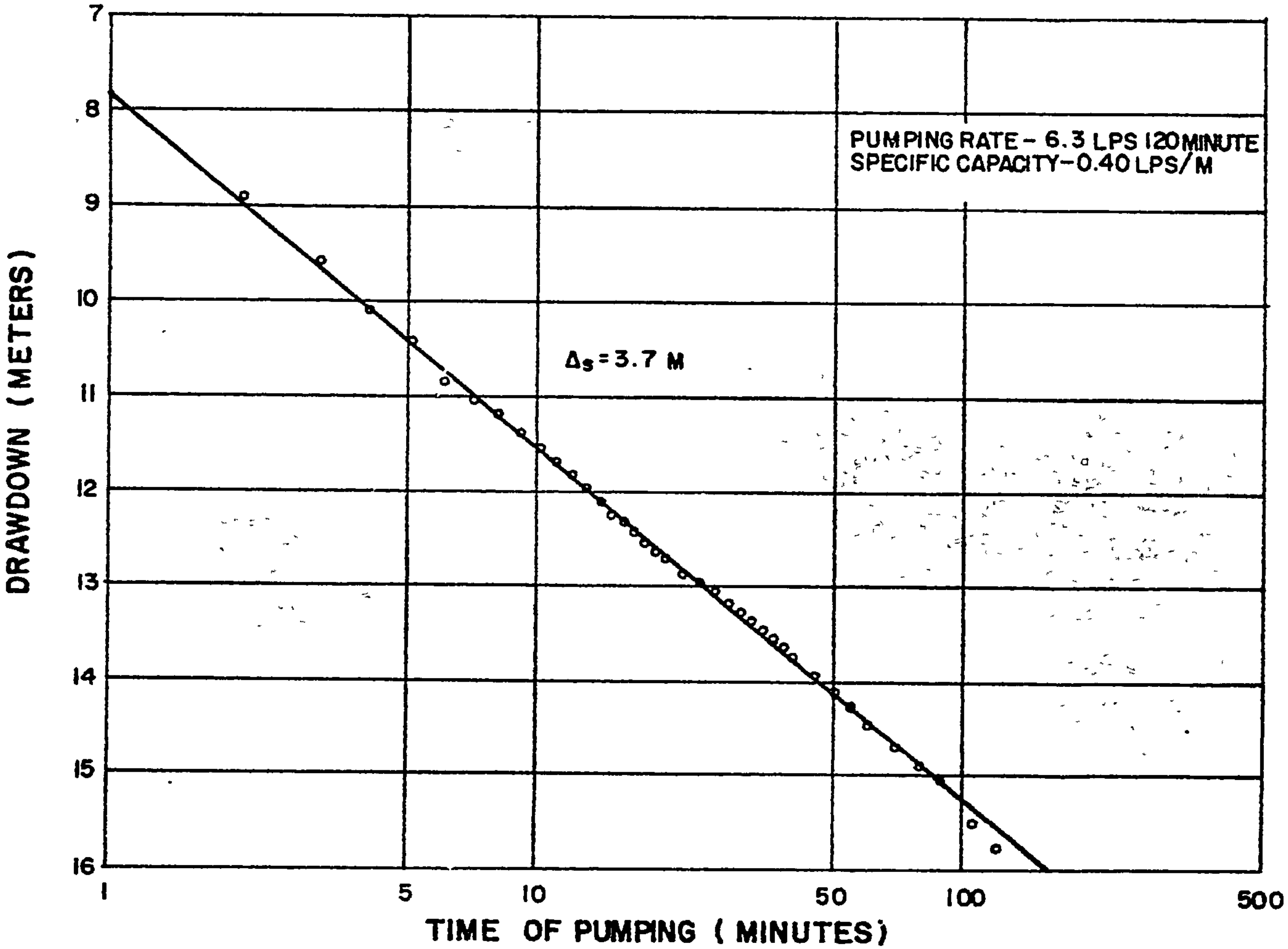


ANALYSIS BY JACOB'S MODIFICATION OF THE THEIS NON-EQUILIBRIUM FORMULA

$$T = \frac{0.183\,Q}{\Delta S}$$

Q = 2176 CUMD
T = 199 CUMD / M

ANNEX FIGURE VII - B -17
CONSTANT RATE PUMPING TEST
PUMPING WELL CDM-7
SAN FERNANDO WATER DISTRICT



ANALYSIS BY JACOB'S MODIFICATION OF THE THEIS NON-EQUILIBRIUM FORMULA

$$T = \frac{0.183Q}{\Delta S}$$

Q = 544 CUMD

T = 27 CUMD/M

ANNEX FIGURE VII-B-18
CONSTANT RATE PUMPING TEST
PUMPING WELL CDM-8
SAN FERNANDO WATER DISTRICT

CHAPTER VIII ANALYSIS AND EVALUATION OF ALTERNATIVES

A. GENERAL

This chapter identifies and evaluates the alternatives for source development, treatment facilities, transmission, distribution system and storage to meet peak-hour demands. Other water conservation and augmentation alternatives are also discussed.

B. WATER SUPPLY SOURCE ALTERNATIVES

Surface Water Sources

The San Fernando River flows through the San Fernando poblacion and the present water service area from north to south. During the dry season, the river flow is very low especially upstream from the San Fernando poblacion. The portion of the river flowing through the San Fernando core area is badly polluted. Since the water of the San Fernando river is badly polluted for municipal water supply use and the minimum flows are too low for the FER-WD requirements in the year 2000, the San Fernando River is therefore not a potential source of water supply.

The major Pampanga River, above 9 km east of San Fernando poblacion near the municipality of San Simon, at Barrio San Juan, has a minimum recorded flow of over 850,000 cumd, almost 30 times the FER-WD requirements for the year 2000.

The use of surface water from Pampanga River would entail the construction of a diversion structure and complete water treatment works. In addition, two sets of pumps are necessary - a set of low-lift pumps to lift raw water to treatment works, and a second set of high-lift pumps to pump treated water to the distribution system.

Another possible source of surface water supply is the rivers of the mountains 20 km or more to the west of San Fernando. A combination of these rivers could supply the FER-WD requirements for the year 2000, since none of these rivers have a minimum flow sufficient to meet this requirement. For these streams to be used as the water source for FER-WD, a combined irrigation-municipal water supply storage dam project is only practical since these streams are widely used for irrigation.

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Analysis of samples from the FER-WD deep wells shows that the chemical constituents are within the acceptable limits of the Philippine National Standards for Drinking Water.

The deep well in Barrio San Pedro has 0.53 mg/l iron content, exceeding the permissible limit of 0.3 mg/l. Iron in trace amounts is essential for nutrition and drinking water containing iron in unpalatable and unesthetic concentration would have little effect on the total daily intake. However, iron and manganese tend to precipitate as hydroxides and stain laundry and porcelain fixtures.

The water from the San Fernando River exceeds the permissible limits for color, turbidity, total dissolved solids, conductivity, manganese, chlorides and total hardness. The water from the Cailugan River exceeds greatly the permissible limits for color, turbidity, total dissolved solids, conductivity, total hardness, calcium, magnesium, sulfate and nitrate.

Water from deepwells within the FER-WD, if designed and constructed with proper safeguards, would not require any treatment. However, in order to preserve the good quality of water throughout the distribution system, disinfection would be necessary at the sources. Disinfection is discussed in detail in Appendix J, Volume II. For economic and practical reasons (ready availability of the equipment, easy supply and application, and lasting effectiveness), chlorination is the recommended process of disinfection.

D. DISTRIBUTION ALTERNATIVES

General

This section presents the distribution alternatives considered for the FER-WD. The recommended improvement program for the water system is discussed in Chapter IX.

The components of a water distribution system and some of the alternatives in planning a system are discussed in Appendix K, Volume II. The design criteria for the distribution system are given in Appendix F, Volume II. Appendices F and K were largely developed for the First Ten Provincial Urban Areas and are applicable to moderate-size communities. The Second Ten Provincial Urban Areas are generally smaller and the parameters presented in Appendices F and K must be applied with discretion.

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Particular attention has been given to the requirements of fire flow in the FER-WD. In general, fire flow is applied at various locations in a system coincidentally with maximum-day demands, and the pipelines are sized to convey the required flow at specified head losses. In large communities, the total peak-hour is greater than the maximum-day flow plus fire flow and therefore relatively minor adjustments are required in the pipe system to provide fire flow. In the smaller communities, especially small barrios some distance from the poblacion, the fire flow alone can be 3 or 4 times the total peak-hour demand.

Providing adequate fire flow to areas where the fire flow may be far greater than the ultimate peak demand is rarely justified economically; but some fire protection should be provided. In this study, information is given on the available fire flow at various locations where the system has been designed for conditions other than fire flow.

The flows used for the design of the various components of the distribution system for the FER-WD are as follows (see Water Demand Projections, Chapter VI).

	1980	1990	2000
Water demand (lpcd)	230	220	225
Served population	16,980	54,650	109,580
Average daily water demand (cumd)	3,910	12,020	24,660
Maximum-day water demand (cumd)	4,690	14,420	29,590
Peak-hour water demand (cumd)	6,840	21,040	43,150

Pressure Zone

The ground elevations within the year 2000 service area would range from a low of 5 meters in Barrio San Nicolas to a high of 30 meters in Barrio Del Rosario. An area with such a small variation in ground elevations could be served from one pressure zone with a HGL of 50 meters. However, the greater part of the service area, including the poblacion, lies at an average elevation of only 6 meters, which could be served at a lower HGL. Serving this area from a HGL of 34 meters (overflow elevation of Dolores storage tank) would mean the utilization of the existing tank and reduction of pumping head over the area with the highest water demand, and thereby reducing operating costs. However, with 34 meters as static HGL the area above the 20-meter contour could not be served adequately. This area could either be served from a separate pressure zone or in the same pressure zone by locating two of the wells at an area above the 20-meter contour. The projected water demand of

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the area above the 20-meter contour is very small compared to the total projected demand of the water district. Serving this area as a separate pressure zone will not have considerable effect on the total number of wells and storage volume requirements of the area below the 20-meter contour. Therefore, serving the whole service area in one pressure zone by locating one well at Barrio del Rosario and one well at Barrio San Isidro to serve the area above the 20-meter contour would appear more cost-effective. The capacity of one well is more than enough to meet the demand of the area above the 20-meter contour. However, two wells are recommended to be constructed in this area because of operational considerations as discussed in the succeeding section. At least one of these wells must be operated at all times during the day to insure adequate pressure and to avoid large pressure fluctuations over the area.

Storage Facilities

Storage facilities are provided in a distribution system to meet hourly fluctuations in demand over the day. The usual requirement for operational storage is 15-20 percent of the maximum-day volume, assuming the source of supply is capable of providing water at a rate equal to maximum-day demand.

In the flat areas of Central Luzon, storage is usually provided by means of an elevated storage tank. This type of tank is very costly in the Philippines because it must be designed to withstand high seismic loadings. An alternative method of meeting demand fluctuations has been investigated for FER-WD.

As previously discussed the least-cost source alternative for FER-WD is pumped groundwater. It is possible to install additional pumping capacity above the maximum-day demand rate in order to meet part of the peak-hour fluctuations and thereby reduce the amount of storage required. The rationale for providing additional pumping capacity and a curve to be used in estimating the required storage volume based on various supply rates is presented in Methodology Memorandum No. 5. An economic analysis comparing the costs of providing additional supply or storage for FER-WD is presented in Table VIII-1.

Table VIII-1 shows that, in the FER-WD, providing additional pumping capacity to meet hourly fluctuations in demand would be less costly than providing extra storage volume. It is recommended that additional pumping capacity be provided in FER-WD and that the volume of storage be minimized.

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TABLE VIII-1

ALTERNATIVE STORAGE VERSUS ADDITIONAL SUPPLY ANALYSIS[1/]

	Alternative 1 (Maximum Storage)	Alternative 2 (Intermediate Storage)	Alternative 3 (Minimum Storage)
Storage Required (%)[2/]	12.53	6.0	2.57
(Volume, cum)	3,500	1,790	760
Present Worth Cost (₱ x 1000)			
Storage[3/]	2,059	1,365	292
Wells	1,867	2,526	3,456
Operation and Maintenance[4/]	189	218	224
Total	₱ 4,115	₱ 4,109	₱ 3,972

Distribution System

The analysis for the distribution system of San Fernando generally followed the guidelines given in Appendices F and K. Unlike the First Ten Areas Feasibility Studies, computer analysis for the Second Ten Provincial Urban Areas considered pipelines smaller than 200 mm in diameter. For a municipality the size of San Fernando, there would be very few pipelines greater than 200 mm in diameter even in the year 2000. Therefore, the minimum pipe size used in the computer analysis is 100 mm.

The distribution analysis did not include studies of various alternative pipeline configurations because the location of the pipes is controlled by the locations of existing and proposed roadways and the barrios to be served. However, the analysis included alternative locations of wells.

1/ Analysis includes all facilities to the year 2000.

2/ Percentage of maximum-day demand.

3/ Includes only additional storage to one 380-cum storage tank; the other 380 cum tank would be abandoned because of its poor structural condition.

4/ Includes differential costs only.

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The location of the wells is partially controlled by the distance between wells to minimize drawdown interference. Another criterion for well location is the location of the centers of demand. Generally, it is cost-effective to locate wells near centers of demand to reduce pipeline sizes in other parts of the distribution system. In locating wells at centers of demand, the capacity of the wells must be considered. Hydraulically, the most efficient well capacity would be equal to the water demand in the area of the well. However, it would be more practical to have wells of about the same capacity for easier operation and control of the pumping rate as demand fluctuates.

It appears that the well capacity in San Fernando would be about 31.5 lps (500 gpm). If wells of this capacity were constructed, relatively few wells would be required. Having few large-capacity wells presents two problems. The first is that the overall cost of pipelines would increase as larger sizes would be needed to supply water to remote parts of the system. The second problem is that, with relatively few large-capacity wells, flow rates could only be changed in large increments. During periods of low demand, the large pumps would have short cycling times. A more efficient method of operation is to have smaller capacity wells so that the operator can control the flow to match the changes in demand closely. The rate of increase in the yearly water demand of FER-WD is gradual, thus, making medium-capacity wells of about 25.2 to 31.5 lps (400 to 500 gpm) more desirable than the high-capacity wells. Distribution main sizes have been analyzed based on the medium-capacity wells. The locations of wells are shown in Figures IX-1 and IX-4. The locations of the proposed wells would have to be confirmed after collecting adequate pump testing data during construction of the initial well. The proposed wells should be coordinated with the NIA to prevent any conflict with the locations of its future irrigation wells. If future well locations and capacities are significantly different from those proposed in this study, additional analyses will have to be made to determine sizes of the distribution mains.

Fire Protection

The distribution system analysis for FER-WD included the investigation of available fire protection in the service area for each design period. The fire flow rates for two types of areas - commercial/industrial or high-density residential area and single-family residential area-are assumed to be 20 lps and 10 lps, respectively, at two adjacent hydrants. (See Appendix K). Available fire flows for areas where full fire protection is not satisfied are presented in this section as percentages of these standards of fire protection. Figure VIII-1 shows the extent of the fire service areas in FER-WD for the year 2000 service area.

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At present, fire protection does not exist in most sections of San Fernando because there is little or no water pressure most of the day. In order to provide fire protection, there must be adequate pressure in all water pipelines 24 hours per day.

The immediate improvement program, which is aimed at providing adequate domestic service to existing consumers and increasing the number of consumers to provide a larger financial base to pay for future improvements, does not include full fire protection. If the program were designed to provide full fire protection to the consumers, the cost of improvements required would become too high for the program to be feasible.

The distribution improvements recommended under the immediate improvement program, including the existing facilities, would be capable of providing 70 to 90 percent of the required fire flow to most sections of San Fernando. However, portions of barrios Dolores and Sta. Lucia which are located at the far end of the service area, would have fire protection of about 35 percent of required fire flow. Some of the existing fire hydrants would require rehabilitation to provide partial fire protection.

For design years 1990 and 2000, the recommended improvements would provide full fire protection for the whole service area since wells spaced at 1 km apart would be operating throughout the service area. To insure fire protection, a general rule is to operate the well nearest the location of fire.

The preceding discussion on fire protection relates only to the capacities of distribution mains. In providing fire protection, an adequate number of fire hydrants also have to be considered for the various service areas. The primary criterion for providing fire hydrants would be the degree of development in a specific area. In Chapter IX, a schedule of fire hydrant construction is included, based on the projected development in San Fernando.

<u>System Operation</u>

This section includes various operational aspects of the alternative distribution systems. While there are no distribution alternatives for San Fernando, there are alternative source locations and source capacities which could present definite operational problems.

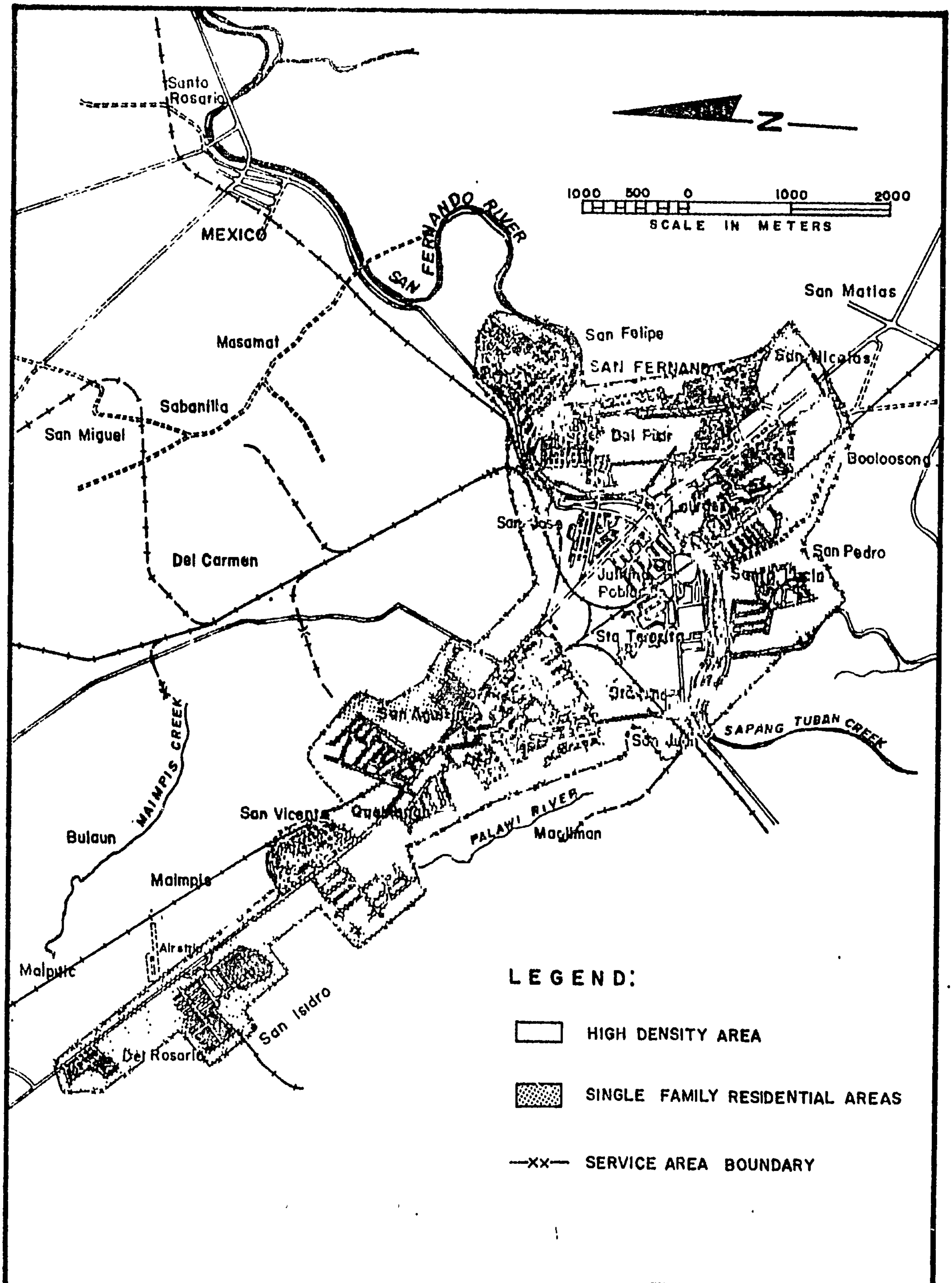

FIGURE VIII-1
FIRE PROTECTION AREA
SAN FERNANDO WATER DISTRICT

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS
LWUA-CDM

As previously discussed, the location and capacity of the wells can affect the operation of the system with regard to meeting demands and pressure requirements. Computer analyses were conducted on several combinations of demands and number of operating wells. In the analyses, only operating problems that commonly occur, such as one well being out of service or an error in judgment as to which wells should be operating, were considered.

Unusual operating conditions, such as meeting maximum or peak demands at minimum pressures when two or more wells are not in operation, were not considered. The cost of providing adequate service under all possible operational conditions would be prohibitive so that only those operating conditions that would reasonably occur were analyzed.

The principal operating problem investigated in San Fernando was when one of the wells has become inoperable. This may occur if one well breaks down or if a well is out of service for routine maintenance. In the area below the 20-meter contour, peak hour could be met with any one well being inoperable. However, if only one well is located in the area above the 20-meter contour and becomes inoperable, minimum pressure even at minimum hour condition could not be attained in this area.

Two alternatives were analyzed to determine the most economical way to solve this operational problem. Alternative 1 is to locate two of the recommended wells, each of 31.5 lps (500 gpm) capacity, in the area above the 20-meter contour line and alternative 2 is to construct two smaller wells equivalent to one 31.5 lps (500 gpm) well in the same area. Table VIII-2 shows the total construction and present worth costs for the two alternatives considered. The analyses indicate that it is more cost-effective to construct two of the recommended wells than to construct two smaller capacity wells equivalent to one 31.5 lps well in the area above the 20-meter contour line. At least one of the two wells located in that area must be operated in any part of the day to insure good pressure.

As a general rule, the distribution system should be operated utilizing as many wells as possible outside the poblacion to meet water demands. This operational procedure has the effect of maintaining a high HGL in the outlying areas, while the storage tank maintains an adequate gradeline within the poblacion.

Besides problems of pressure in the system due to well operation, the schedule of operation has also to be considered. The pump operation schedule is based on the water level within the tank and pressures in various sections of the system. If the tank level drops, a sufficient number of wells would have to be operated to refill the tank. However, the major problem in this operation schedule is the time available to control the number of wells in operation as the water level and pressure fluctuate.

As experience is gained in the operation of wells, a schedule of operation based on normal demand schedules may be devised. If a satisfactory schedule is devised, the system may go unattended for several hours.

TABLE VIII-2

ALTERNATIVE ANALYSIS ON OPERATIONAL PROBLEM[5/]

	Construction Cost (₱ x 1000)		Present Worth Cost (₱ x 1000)	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Wells[6/]	968	1,452	59	88
Pumping Station	206	315	14	22
Pipeline	726	440	39	24
Total	1,900	2,207	112	134

<u>Internal Network</u>

A general discussion of the internal network for distribution system is included in Appendix K, Volume II. The small size of the FER-WD does not affect the application of the recommendations contained in Appendix K since these are the minimum pipeline sizes recommended for any city.

E. ALTERNATIVES FOR WATER CONSERVATION AND AUGMENTATION

In San Fernando, groundwater is also used for irrigation and other purposes. There is a possibility for the groundwater source to be overpumped, causing a decline in water availability in the area. Steps should be taken to conserve water and possibly to augment present sources.

There are several alternative measures for conserving water. These alternatives depend on sophisticated technology in the case of water reuse and desalting or on governmental policy in the case of land management. Appendix M, Volume II is a discussion of these conservation and augmentation alternatives.

5/ Facilities common to both alternatives are not included.

6/ Costing is for one-500 gpm well for alternative 1 and two-250 gpm wells for alternative 2.

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ANNEX VIII-B

SCHEDULE OF FACILITIES FOR ALTERNATIVE STUDIES

ANNEX TABLE VIII-B-1

ECONOMIC SERVICE LIFE OF WATER SUPPLY FACILITIES[1]

Item	Economic Service Life (Years)
Embankment Dams[2]	
Embankment	50
Structure	50
Equipment	50
Water Treatment Plants	
Structure	50
Equipment	15
Groundwater Wells	
Well	25
Structure	50
Equipment	15
Transmission Facilities	
Pipes	50
Valves	50
Distribution Facilities	
Pipes	50
Valves	50
Internal Network	
Pipes	50
Valves	50
Hydrants	50
Service Connections	
Service Pipes	50
Water Meters	15
Disinfection Facilities	
Structure	50 (may depend on
Equipment	15 associated facility)
Storage Facilities	
Structure	50
Equipment (specialized, other than pipes and valves)	15
Miscellaneous Structures	50
Miscellaneous Mechanical Equipment	15
Vehicles	7

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[1] The economic service lives presented here have been used throughout this report whenever facility replacement or present worth analysis has been required.

[2] Although the physical life expectancy of certain facilities, such as dam embankments, is greater than the economic service life indicated, the latter more realistically reflects the useful life of the facility.